(e) *Exploratory schemes*

The Bureau is continuing to test various minerals for their capacity to remove sulfur oxides from flue gas. Materials found active might either be discarded after a single pass, or regenerated. Many minerals such as *shales* and phosphate rock contain compounds known to react with SO_2 under certain conditions.

The most promising materials found in these laboratory tests will be studied further, using an actual flue gas from combustion of pulverized coal. Both a small and a large coal-fired furnace are available for such studies.

(5) Other sulfur control research

Interest and concern for sulfur-based air pollutants and their control is not only nationwide, but is springing up throughout the world. Foreign countries reporting particular activity in sulfur-control research and development include England, Germany, and Japan. Although work is under way in many areas on means for fixing sulfur during combustion, the most important advances have been made in the recovery of SO_2 from stack gases. The foreign countries where such research is under way, and the scale of experimentation involved are indicated in the following table:

Process	Location	Size of installation (megawatts)	Byproduct
1. Alkalized alumina	England	[1] 50	Sulfur.
2a. Catalytic oxidation	United States	12	Sulfuric acid.
2b. Catalytic oxidation	Japan	.02	Ammonium sulfate.
3a. Reinluft (activated char)	England	[2] 15	Sulfuric acid.
3b. Reinluft (activated char)	Germany	5	Do.
4. Activated char	Japan	1.9	Do.
5. Manganese oxide	do	2	Ammonium sulfate.

[1] Proposed. [2] No longer in operation.

It is particularly interesting to note that of the four differing approaches to SO_2 recovery represented in the table, the Department of the Interior, through the Bureau of Mines, has contributed important pioneering research to three.

(6) Summary

With increasing urbanization, growing population, and associated industrial expansion, sulfur oxide concentrations in the atmosphere over our cities will increase unless some limitation is placed on their discharge. Since most of the sulfur oxides result from burning coal and residual fuel oil, the problem already is recognized by legislation that sets specifications for fuels to be used in Federal facilities, electric utilities, and industrial plants.

While the United States has appreciable reserves of low-sulfur coal, much of it is located at too great distance from the electric utility market—the major user—or is held captive by the steel industry for metallurgical purposes. Neither is there a sufficient domestic supply of low-sulfur residual fuel oil to meet demands now met principally by imports of high-sulfur residuals. For these reasons, unless research finds a solution to the sulfur-emission problem, restrictions will inevitably put a stop to the use of high-sulfur fuels and result in increased costs.

Natural gas conceivably could offer an acceptable alternative if it were available in sufficient quantity. However, this is one of the highest-quality, most convenient energy resources in the country. Conservation principles require us to consider future, as well as present needs. Proved reserves of natural gas are sufficient for between 16 and 17 years of consumption at the present rate. Without doubt, more natural gas will be discovered in the future, but any general shift to this fuel would raise requirements to more than offset increased supplies.

Nuclear power presents another possible answer to the sulfur dioxide problem. Great advances have been made in the development of nuclear reactors, but there is still much to be learned about their economic and safe operation. The handling and disposal of nuclear waste is another problem. Supplies of low-cost fissionable material are limited and will continue to be so unless new reserves can be discovered or until breeder reactors become practical.

While theoretically sound ways to solve the sulfur oxide problem are known, all processes under study to date are either technologically incomplete or economically unfavorable. The lowest cost routes for a variety of conditions are still to be determined, and new and improved methods must be sought.