

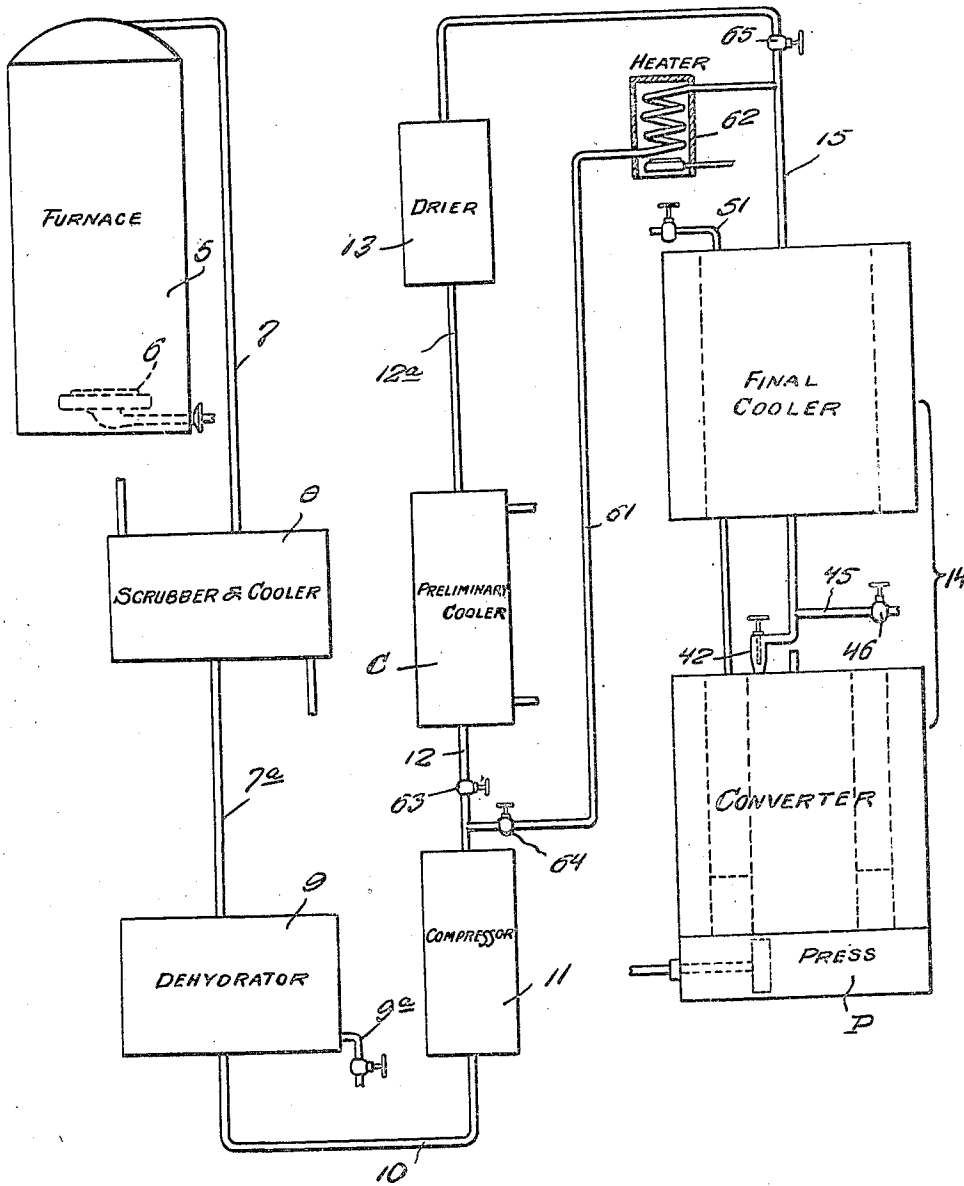
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PROCESS OF PRODUCING SOLID CARBON DIOXIDE

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PROCESS OF PRODUCING SOLID CARBON DIOXIDE

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This invention relates to a process of and apparatus for producing solid carbon dioxide from dried flue gases occasioned by burning natural gas with air and composed of about ten per cent carbon dioxide gas and about ninety per cent nitrogen.

More particularly, the present invention contemplates a process and apparatus by means of which the carbon dioxide may be effectively separated as a solid from the nitrogen without the use or aid of a separate supercooling or refrigerating unit such as is included in the apparatus disclosed in the pending application of Joseph S. Belt and Hamilton P. Cady, Ser. No. 424,655, filed January 30, 1930.

More particularly, the present invention contemplates compressing and cooling the dried flue gases within predetermined limits so that when the compressed and dried flue gases are expanded into a converting chamber, a large percentage of the carbon dioxide will be solidified and separated from the nitrogen without the aid or use of a separate supercooling or refrigerating unit.

The invention will be evident from the following description when considered in connection with the accompanying drawing, in which the figure is a diagrammatic view, partly in section, of an apparatus suitable for carrying out the present process.

Referring in detail to the drawing, 5 indicates a furnace which has a burner 6 supplied with natural gas from a suitable source, and also supplied with sufficient air to furnish the necessary oxygen for substantially complete combustion of the hydrocarbon constituents of the natural gas. A pipe 7 conducts the flue gases from the furnace 5 through a scrubber and cooler 8, in which acids and odors are removed from the flue gases, and in which the water vapor of the hot flue gases is condensed. A pipe 7a leads from the scrubber and cooler 8 into a dehydrator 9, where most of the water is separated from the remaining gases, then collected and drawn off through a suitable outlet 9a. The gases pass from the dehydrator 9 through a pipe 10 to a conventional multiple stage compressor 11 having the usual intercoolers and after cooler. Further mois-

ture is expressed from the gases in the compressor and drawn off as necessary in any well known or preferred manner. The compressed and cooled gases are then conducted by a pipe 12 to a preliminary cooler —C— where they are reduced in temperature to 60° F., or lower. From the cooler —C—, the gases are conducted by pipe 12a to an absorbent drier 13, where any remaining trace of moisture may be removed from the gases so that it will not be present for freezing in and clogging the coils of the final cooling and converting device 14 to which the gases are conducted from the drier 13 by a pipe 15. The compressor 11 is adapted to place the gases under a pressure of between 2900 pounds and 4000 pounds, and the final cooler of the device 14 is adapted to reduce the temperature of the compressed gases to from -62° centigrade to -73° centigrade, depending upon the pressure used.

The compressed, dried and cooled flue gases are expanded through a valve 42 into the converting chamber as they pass from the final cooler to the converter of the device 14, and this expansion is so regulated that the pressure of the gases within the converting chamber is about 10 atmospheres or 150 pounds. By thus expanding the flue gases, they reach a temperature of -104° centigrade within the converting chamber, and due to the Joule-Thompson effect, a large percentage of the carbon dioxide gas is converted to a solid. I have found that with a pressure of 4000 pounds, the flue gases may be reduced to a temperature as low as -73° centigrade in the final cooler without danger of converting the carbon dioxide gas to a solid and clogging the coils of the final cooler, the carbon dioxide gas not solidifying until it is expanded through the valve 42 into the converting chamber. The unsolidified carbon dioxide gas and nitrogen are allowed to escape from the converting chamber in any suitable manner and pass through the final cooler for cooling the dried and compressed flue gases in advance of expansion of the same to the temperature of from -62° centigrade to -73° centigrade as mentioned above. These escaping gases flow from the

final cooler to the atmosphere by way of pipe 51. As the carbon dioxide gas is converted to a solid within the chamber of the converter, it falls to the bottom of said chamber and passes therefrom into a suitable press —P—, where the solid carbon dioxide is compacted and subsequently cut into block form for commercial use.

It is noted that the Joule-Thompson effect is much greater for a mixture of carbon dioxide and nitrogen than for nitrogen alone, and when the dried and compressed flue gases are reduced to a temperature as low as -73° centigrade, in the final cooler, the cooling produced upon expansion into the converting chamber has been found sufficient to separate nine-tenths of the carbon dioxide from the mixture without the use of a supercooler. However, with a highly efficient expansion chamber which is well insulated from heat leaks, expansion from a pressure of about 3000 pounds to a pressure of 150 pounds will be sufficient to produce the cooling necessary. Obviously, however, the exact pressure and temperature used for the gases immediately prior to expansion will depend upon the efficiency of the plant, higher pressure being needed to compensate for lower plant efficiency. Under all conditions, however, the pressure in the expansion chamber will be substantially ten atmospheres or 150 pounds, and the temperature within the expansion chamber, produced by expansion of the gases, will be substantially -104° centigrade.

A by-pass connection 61 may be provided between the compressor 11 and the final cooler, a heater 62 being included in this connection. A valve 63 is provided to shut off the flow of gases to the preliminary cooler —C— and to cause the gases to flow through the by-pass 61 when the valve 64 in the latter is opened. A further valve 65 is provided in the pipe 15 to prevent the gases from passing from by-pass 61 into the drier 13 and the cooler —C— when valve 63 is closed and valve 64 is open. A vent pipe 45 leads from the inlet side of expansion valve 42 so as to discharge to the atmosphere, and this vent pipe has a suitable shut-off valve 46 therein.

In operation, the flue gases which are generated in the furnace 5 are passed to the scrubber and cooler 8 to have acids and odors removed therefrom and the water vapors therein condensed. The water of condensation is then removed by the hydrator 9, after which the gases are placed under a pressure of from 2900 pounds to 4000 pounds by the compressor 11. The gases are then slightly cooled by the cooler —C—, after which any remaining trace of moisture in the gases is removed therefrom by the absorbent drier 13, before the gases pass into the final cooler of the device 14. The compressed and dried

flue gases then flow through the final cooler and are discharged through valve 42 into the chamber of the converter, expanding in the latter so as to reduce the pressure of the gases thereof to about ten atmospheres. Upon continued operation of the apparatus, the temperature of the gases expanded to ten atmospheres in the chamber of the converter is lowered by the Joule-Thompson effect to about -104° centigrade so that most of the carbon dioxide gas is changed by direct transition from a gas to a solid in the form of snow or frost. This snow or frost passes downwardly and is discharged into the press —P— for being compacted and subsequently cut into block form for commercial use. The nitrogen and unsolidified carbon dioxide pass from the converter through the final cooler countercurrent to the gases passing from the drier 13 through said cooler to the expansion valve 42. In this way the compressed and dried flue gases are effectively cooled by the escaping gases to from -62° centigrade to -73° centigrade, immediately before they are expanded through the valve 42 into the converting chamber. The exact temperature to which the flue gases are cooled before being expanded through the valve 42 will depend upon the plant efficiency and the pressure used.

To defrost or remove any frozen matter which might clog the coils of the final cooler due to faulty operation or improper care of the apparatus, the gases are caused to flow through by-pass 61 so as to be heated by the heater 62, the hot gases being discharged through vent pipe 45 by opening its valve 46 and closing the expansion valve 42.

In practice, the scrubber and cooler 8 and the dehydrator 9 may be combined in a single unit, the same being merely shown as separate elements for the sake of clearness. The same is also true with respect to the final cooler and the converter. These devices, as well as the elements 11, —C—, 13 and —P— may be of any preferred type or construction. However, the final cooling and converting device 14 is preferably of the general type disclosed in the pending application of Robert B. Dickey Ser. No. 486,764, upon Apparatus for producing solid carbon dioxide.

What I claim as new is:

1. The improved process of producing solid carbon dioxide from flue gases composed of about 90% nitrogen and 10% carbon dioxide, which consists in drying the flue gases, placing the dried flue gases under a pressure of between 2900 pounds and 4000 pounds, expanding the dried and compressed flue gases to about 150 pounds into a converting chamber, permitting escape of the nitrogen and unsolidified carbon dioxide gas from the converting chamber, and utilizing the escaping nitrogen and unsolidified carbon dioxide gas

to cool the compressed and dried flue gases immediately in advance of expansion thereof to a temperature of between -62°C. and -73°C. , whereby the flue gases are reduced to a temperature of -104°C. when expanded into the converting chamber.

2. The improved process of producing solid carbon dioxide, which consists in generating flue gases composed of about 90% nitrogen and 10% carbon dioxide and containing acids and odors, removing odors and acids from and substantially dehydrating said flue gases, compressing the dehydrated gases to between 2900 pounds and 4000 pounds, then preliminarily cooling said compressed gases and removing any remaining trace of moisture therefrom, then expanding the compressed flue gases to a pressure of about 150 pounds within a converting chamber, and utilizing nitrogen and unsolidified carbon dioxide gas from the converting chamber for finally cooling the compressed flue gases to a temperature between -62°C. and -73°C. immediately in advance of expanding said flue gases, whereby the flue gases are lowered to a temperature of -104°C. when expanded in the converting chamber.

3. The improved process of producing solid carbon dioxide from flue gases composed of about 90% nitrogen and 10% carbon dioxide, which consists in drying the flue gases, placing the dried flue gases under a pressure of between 2900 pounds and 4000 pounds, expanding the dried and compressed flue gases to about 150 pounds into a converting chamber, permitting escape of the nitrogen and unsolidified carbon dioxide gas from the converting chamber, and cooling the compressed and dried flue gases immediately in advance of expansion thereof to a temperature of between -62°C. and -73°C. , whereby the flue gases are reduced to a temperature of substantially -104°C. when expanded into the converting chamber.

4. The improved process of producing solid carbon dioxide from flue gases composed of about 90% nitrogen and 10% carbon dioxide, which consists in placing the gases under a pressure between 2900 and 4000 pounds, expanding the compressed gases to a pressure of about 150 pounds within a converting chamber, and cooling the compressed flue gases to a temperature of between -62°C. and -73°C. in advance of expanding the same within the converting chamber, whereby the expanded gases are brought to a temperature of substantially -104°C. within the converting chamber to solidify approximately 90% of the carbon dioxide.

In testimony whereof I affix my signature.
J. S. BELT.