January 1941
Claim for an Invention from F. Lange and V. Maslov, 'Thermocirculation centrifuge'

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Summary:

This document's proposal about centrifuge received positive assessments from the leading Soviet academicians in Moscow.

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Claim for an Invention from F.Lange and V.A. Maslov
"Thermocirculation Centrifuge"

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This paper proposes a method for uranium isotope separation in a more effective and simpler way than the method of the multi-chamber centrifuge, proposed by us as a complement to the proposal № 5303.

The thermocirculation centrifuge method, similar to the well-known thermal diffusion method of isotope separation, is a combination of two processes: the actual separation process (in our case - centrifugation) and an auxiliary process - thermocirculation. Of course, in terms of effectiveness, thermal diffusion and the method proposed by us cannot be compared, because the degree of separation achieved by centrifugation is thousands of times higher than during thermal diffusion. In this case, the economic side of the issue is not under consideration, since it is well known that, in the thermal diffusion method for the uranium enrichment using the light variety of the aforementioned, as much energy can be spent as is isolated from the uranium in its future use. The costs associated with multichamber process, and with thermocirculation, are very low (they expend energy only through the rotation of the vessel and the change of a temperature of about one degree).

The essence of the thermocirculation centrifugation method is the following.

Let us assume that we have a cylindrical vessel A (Fig. 1) filled with a mixture of vapors of any two substances. The centrifugal force will act on the cylinder contents during rotation around the axis SS. Consequently, from the periphery toward the center along the radius of the vessel there appears some (in accordance with the circumferential speed) difference in concentrations. At the same time, the difference in concentration over the entire height (in all the cross sections of the cylinder and perpendicular to its axis) will be equal. Let us assume now that we created two streams in the cylinder. One stream is the one which is top-down running along the periphery and the other one is running bottom-up along the axis of the cylinder.

Obviously, the presence of such a vapor mixture flowing through its movement to the bottom along the vessel walls will be continuously enriched with the heavier component (in the case of uranium compounds centrifugation - molecules containing the heavy isotope of the aforementioned), in the same time the mixture of vapors which are moving upward along the axis, will be enriching with the lighter component (in the case of uranium - molecules containing its light isotope). This process is quite similar to heat circulation in the process of thermal diffusion.

Obviously, an increase in concentration along the cylinder axis will proceed very quickly, because the mixture in each subsequent cross-section is enriched a number of times [and has been] already enriched the same number of times during the previous cross-section mixture, etc. Hence, it is clear that the combination of the centrifugation with the above-mentioned flows and with a sufficiently large vessel length (about a meter) even during relatively low circumferential speeds (from 100 to 200 meter per second) a very high degree of enrichment can be achieved, which can be placed in tanks which are located in the upper and lower parts of the cylindrical vessel. At the same time the mixture from the upper tank will be enriching with the light component and from the bottom tanks with the heavy component.

It is convenient to have in these tanks enriched mixture in liquid form, because in this case we can have a significantly larger amount of the processed material in the same volume. Maintaining the material in the tanks in the liquid phase can be always achieved by adjusting the temperature or simply by increasing the diameter of the cylinder at the places where tanks are located (these are annular vessels, where the side surface of the cylinder serves as an outer wall), which will correspondingly increase the pressure in the aforementioned.

The second method is preferable, because the overall increase in temperature leads to a decrease in the separation index and the efficiency of the method. Creating flows along the periphery (from the top to bottom) and along the axis (from the bottom to upward) can be accomplished by specifying very small (around one or a few degrees) differences in temperature between the periphery and the central part of the vessel (the central part should be warmer).

The existence of a temperature difference leads to the fact that, as a result of gravity, the less warm, and therefore heavier, layers of the mixture around the periphery, will fall down and the warmer, therefore less dense, vapor mixture layers around the internal wall of the cylinder, will rise up, i.e. the temperature difference between the periphery and the center will lead to thermocirculation.

The temperature difference between the periphery and the central part of the vessel can be created by placing the concentrically located cylindrical vessel with a small radius inside the last heated cylinder B (see. Fig. 1). This inner cylinder may be heated either by an electric furnace, or passing a flow of warm gas or liquid through it. To create a temperature gradient in the vessel, the friction with the air, which takes place during rotation of the vessel, can be used. It is sufficient to simply leave the inner cylinder open from below; thereby, due to worsened conditions for heat loss, the central part of the vessel, despite a lower peripheral speed, will be warmer than the periphery - the outer cylinder.

Another possibility for the use of thermocirculation is equalization of the respective concentrations between the periphery and the centers of the two adjacent chambers of the multi-chambered centrifuge. This circulation method has very substantial advantages in comparison to other methods.

Chief of these is the automatic exclusion of the possibility of mixing the cell's contents along the radius, which is caused by the circulation flow between adjacent chambers. This mixing can be especially reliably prevented by maintaining the chamber's contents at a temperature midway between temperatures in the periphery, i.e. the cylinder's outer walls and the center. Indeed, the heat flows entering the central part will be wrung from the chamber's center to the walls that are facing the center of the chamber; and cold flows arriving at the periphery will also be wrung from the center of the chamber to the periphery of the vessel. By this, the mixing will be prevented.

Another advantage of thermocirculation is the simplicity of its implementation (neither special pumps, nor taking into account vibration component of the main spin speed of the centrifuge are needed) and, of course, low cost of manufacture and use.

An exemplary design of thermocirculation between two adjacent chambers of the multi-chamber centrifuge is shown in Figure 2 [where] A and B - the cell, SS - the rotation of the centrifuge axis. The arrows indicate the direction of circulation. At station cd, the mixture is heated, causing it to rush from the periphery to the center and enter into the central part (facing towards the center) of the chamber A. At the same time, instead of the departed gas, new gas from the peripheral part of the chamber B enters into the channel C. At area ab gas is cooled, and centrifugal forces push it towards the periphery, entering the peripheral part of the cell B, and then - again through channel C into the central part of the chamber A. The gas flow departs from the channel D, draws the gas through the channel E from the central part of the chamber A.

It should be noted that in addition to uranium isotope separation, this method, as well as the multi-chambered centrifuge method can lead to the obtainment of extremely effective results for light elements, because the aforementioned elements have a very high vapor pressure even at very low temperatures. At low temperatures, the degree of separation, as well as the performance of these methods must be ten times higher, since the temperature in respective terms is included in the denominator. A decrease in temperature should particularly strongly affect the increase of the separation degree, because in this case, the temperature is in the denominator of the exponent.

So, this letter proposes the following:

1) the thermocirculation centrifugation method;

2) thermocirculation application in order to equalize concentrations between corresponding elements of the two adjacent chambers of the multi-chamber centrifuge;

3) increasing the effectiveness of the thermocirculation and multi-chamber centrifuge methods using low temperatures;

4) the friction (in rotation) with the air usage to create a temperature gradient within the centrifuge;

5) maintaining the enrichment process in the gaseous form while the treated substance in tanks is in a liquid form.

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