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PRESSURING METHODS OF DEWAR RECIPIENTS AIMING THE COOLING AGENTS' TRANSFER INTO THE MECHANICAL TEST ENCLOSURE

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ABSTRACT:
The paper aims at presenting three constructive solutions to obtain the pressurizing of the Dewar recipient containing the cooling agent, as well as a version for a stopper, meant to secure and pressurize the recipient. Thus, the usage of a device adjusting temperature automatically ensures low temperatures within the refrigerating enclosures, these being necessary for the mechanical tests.

KEYWORDS:
Dewar, low temperature, pressurization

1. GENERALITIES

Regarding chill users in the case of laboratories destined for mechanical tests, one uses substances or blends of substances, which create the desired low temperature inside the refrigerating (or cryogenic) enclosures.

Therefore, what material mechanical tests are concerned, we aim at using the following terminology, without changing their definitions:

- *Refrigerant* - the cold conductor surface
- *Cooling medium* - the substance through which the heat transfer between the refrigerating agent and the sample is achieved
- *Coolant* - the blend (in certain amount) between the refrigerating agent and the cooling environment.

Remark: In case the material mechanical tests are conducted at -196^0 C (77 K), the cooling of the test samples is done in liquid nitrogen, the latter playing both the role of a refrigerating agent and of the cooling environment, as well as cooling agent.

The *refrigerant* employed for such tests is a substance, that, when subjected to melting, vaporization or sublimation, in other words by passing from one state of aggregation to another, it undertakes the heat of the surrounding medium.

Refrigerants are required to meet a varied range of conditions, often rather contradictory, such as: to be harmless against the human body; to display chemical stability and passivity to corrosion; to be fireproof and show no danger of explosion; the mass volume of vapors and the mass heat of liquid should be low; high coefficients for heat conductivity and high vaporization heat; low cost price, etc.

In industrial laboratories, one uses the following refrigerants in order to obtain low temperatures: ice (solid H_2O), solid carbon dioxide (CO_2) (carbonic snow) and liquid nitrogen (N_2). On the other hand, for low and very low temperature tests (cryogenic temperatures), within specially equipped laboratories, one uses a different range of refrigerators: liquid nitrogen (N_2), liquid helium (He) and liquid hydrogen (H).

Furthermore, the *cooling medium* is the very substance that undertakes the refrigerant and transmits it to the test samples placed inside a refrigerant enclosure and meant to be tested at a certain load. Nevertheless, this also meets the adjusting function of the cooling temperature, at the desired value.

Thus, the cooling medium provides the heat necessary for the refrigerant to pass from one state of aggregation to another; hence, its temperature is decreasing. The higher the quantitative proportion between the refrigerant and the cooling medium, the more evident the temperature decrease. Likewise, the higher the refrigerant's melting, vaporization or sublimation, the more rapid the temperature decrease.

By mixing (in certain proportions) a refrigerant with an adequate cooling medium, one obtains a *coolant*, proper to the low temperature necessary for material mechanical tests.

2. CONSTRUCTIVE SOLUTIONS OF OBTAINING THE PRESSURIZATION OF THE DEWAR RECIPIENT

In the case of using liquid nitrogen as a refrigerant, one will need to deposit it into a recipient of Dewar type. Subsequently, Dewar recipients of 40 l capacity have been involved in conducting the experiment.

However, choosing the pressurizing version of such a Dewar recipient entails a series of factors: the usage manner of the refrigerant (liquid nitrogen or nitrogen vapors); the refrigerant flow; the desired low temperature; the achieving and adjusting mode of the flat-level temperature; the constructive solution of the refrigerating enclosure, as well as the aimed usage domain (mechanical tests, cryogenic hooping, chipping in cryogenic conditions, cryogenic treatments, etc.)

Thus, the performed experiments have used 3 pressurizing versions of the Dewar recipient, which are sketched in Figure 1.

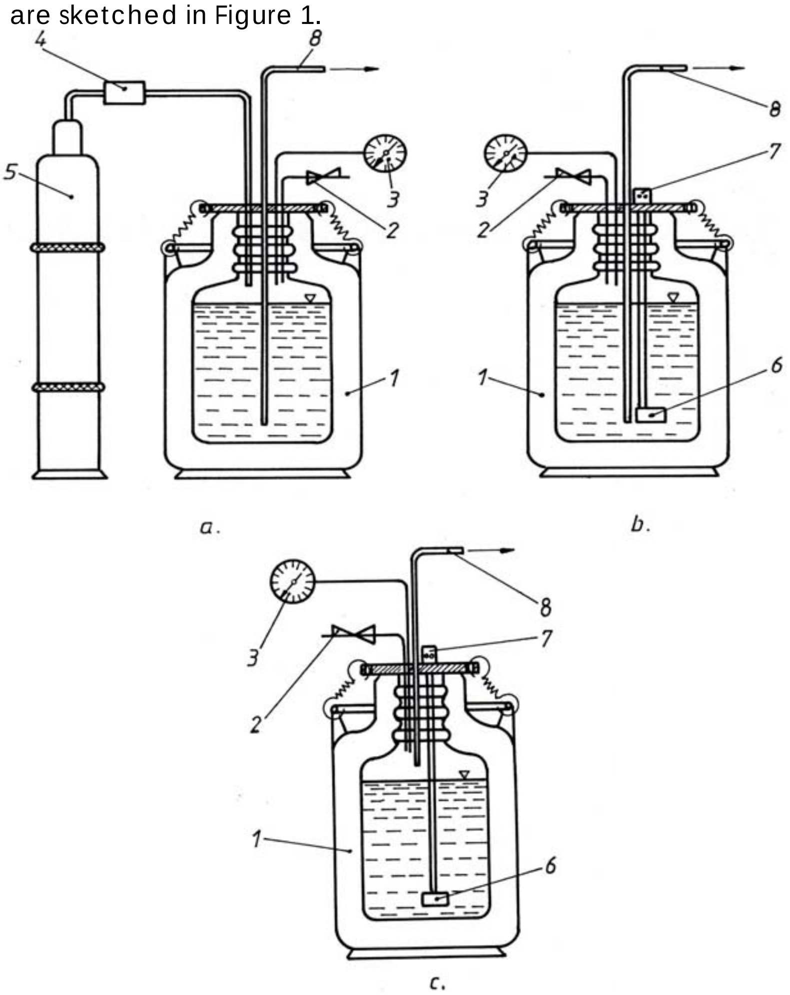

Figure 1. Pressurizing versions of the Dewar recipient

Version I displays pressurizing with gas nitrogen (Fig.1.a). Consequently, gas nitrogen is introduced from the storage vessel (5) into the Dewar recipient (1) through the pressure reducer (4), at a well-established pressure (smaller than ρ_{max}= 0, 05 Mpa), also depending on the necessary liquid nitrogen flow. Due to the pressure created in the space between the recipient's stopper and the liquid nitrogen surface, the latter is evacuated from the Dewar recipient through a transfer pipe (8). A safety valve (2) and a pressure gauge (3) are set up at the recipient's stopper (of special construction).

Version II assumes pressurizing with nitrogen vapors (Fig.1.b.). Such a medium is achieved by heating the liquid nitrogen from the Dewar recipient through a load resistance (6) immersed in liquid. The heating regime of the electric resistance is driven by an automatic system for adjusting low temperature, the resistance being socket-charged. The obtained nitrogen vapors will fill the space between the recipient's stopper and the liquid nitrogen surface, so after reaching a certain pressure, the liquid nitrogen is evacuated by means of a transfer pipe (8). The stopper is provided with a safety valve (2) and a pressure gauge (3).

Version III allows the usage of nitrogen vapors as a refrigerant (Fig.1.c.). The liquid nitrogen storage in the Dewar recipient (1) is heated by an immersed electric load resistance (6), thus obtaining nitrogen vapors at the Dewar's upper part; these are evacuated through a transfer pipe (8). The charging of the electric resistance is done through a socket (7). The pressure gauge (3) indicates the pressure of the nitrogen vapors, whereas the safety valve (2) ensures the maintaining of the current pressure.

3. THE CLOSING, ENSURING AND PRESSURIZING DEVICE OF THE DEWAR RECIPIENT

In order to achieve the pressurizing of the Dewar, it is necessary that these recipients be closed at the upper part, with the aid of special construction devices (stoppers). Consequently, so as to be able to accomplish version II and III (see Fig.1.b. and Fig.1.c.), a stopper just like in Figure 2 was conceived.

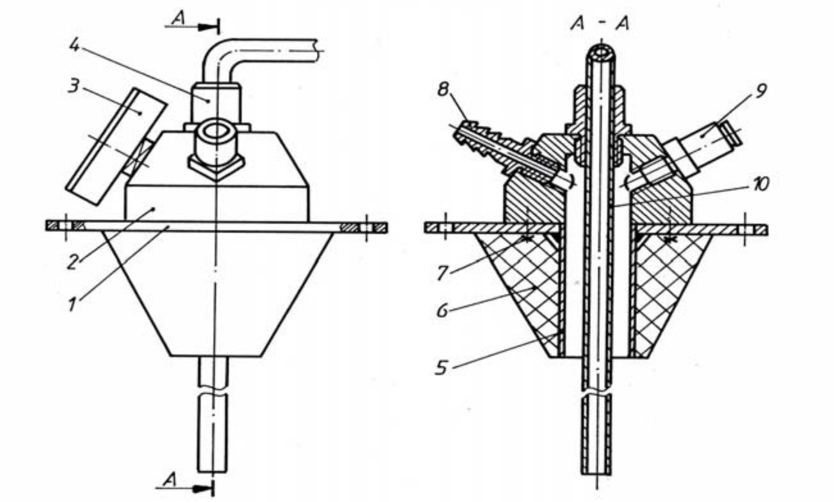

Figure 2. Stopper for achieving the pressurizing versions II and III

The stopper is made up of a Teflon body (1) with four longitudinal holes. The copper pipes (9) pass through two of the holes; these pipes are tied together at their lower part through an electric load resistance (8), fastened by copper screws.

Therefore, at the upper part, the pipes are threaded and fastened in the stopper's body with the aid of screw nuts (11). The electric load resistance consists of nickel wire (ϕ 4 mm) and serves for heating the liquid nitrogen it is immersed in.

The charging of the electric resistance is done by the pipes (9), which are connected to the low temperature adjusting system. Furthermore, two Teflon sleeves (10) are set up onto the charging pipes; these sleeves prevent the contact (even of accidental nature) between the pipes and the corrugated tube from the lower part of the Dewar recipient's neck.

Remark: A manifold of tests were necessary to establish the constitutive material of the electric load resistance, as well as the diameter of the used wire. This happened owing to the phenomenon known as the metal's super-conductibility, which occurs in such experimental conditions, namely when is being immersed in liquid nitrogen at -196^{0}C. Thus, the conclusion drawn revolves around the fact that nickeline is the adequate material for usage, whereas the wire diameter and windings were established experimentally.

The pressure gauge (4) is set up onto the stopper's body with the aid of the copper screw nut (1) and a prolongation pipe (2), also made up of Teflon, threaded within one of the stopper's holes.

The last orifice in the stopper's body serves the purpose of setting up the Teflon-made part (12), to which a safety valve (5) is attached; this attachment is achieved through a coiled copper pipe. (12) has a pierced longitudinal hole, which is threaded at the upper part, thus allowing the mounting with a transfer pipe (not depicted in the figure).

The stopper's body is taper-shaped; this allows a proper fitting and centering at the neck of the Dewar. Four calibrated springs will be used in order to fit the stopper onto the recipient; these springs are to be set up between the stopper's and the recipient's peripheral orifices.

4. DEVICE FOR AUTOMATIC ADJUSTMENT AT LOW TEMPERATURES

In order to achieve a more precise adjustment of low temperatures, the author has come up with a device for automatic temperature adjustment (D.R.A.T.S).

Any manual adjustment is removed thanks to this device, which can be applied to version II and III of Dewar pressurizing. Liquid nitrogen is the refrigerator in this case.

The most accurate results were obtained for the 3rd pressurizing version, because the device has the possibility of achieving both an adjustment for the immersed electric resistance (a certain temperature and flow are obtained for the nitrogen vapors) and a fine adjustment for the resistance that ensures the final temperature of the nitrogen vapors.

The *temperature transducer* converts the non-electric value (temperature) into an electric one (resistivity variation), whereas *the "resistance voltage" converter block* transforms the resistance variation of the thermal resistance into a voltage variation.

The *display system* is a digital milivoltmeter displaying the voltage supplied by the resistance-voltage converter, voltage that is proportional to the measured temperature.

The *temperature specification block* supplies a well-established benchmark voltage, which is proportional to the specification temperature aimed for and can be altered by a potentiometer.

The *comparator block* determines the deviation between the real temperature, from the workroom of the refrigerating enclosure, measured by the thermal resistance, and the temperature imposed by the specification block.

The resulting comparator's outgoing voltage is amplified and brought to the proper parameters for controlling the *voltage regulator block*. This one supplies an adjustable voltage, depending on the temperature one desires to obtain inside the refrigerating enclosure.

The execution element, which is an electric resistance, more or less heats the coolant (nitrogen vapors with the resistance R_s), as well as the refrigerant (liquid nitrogen, with an immersed load resistance R'_s), depending on the temperature supplied by the voltage regulator and the specified temperature.

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