

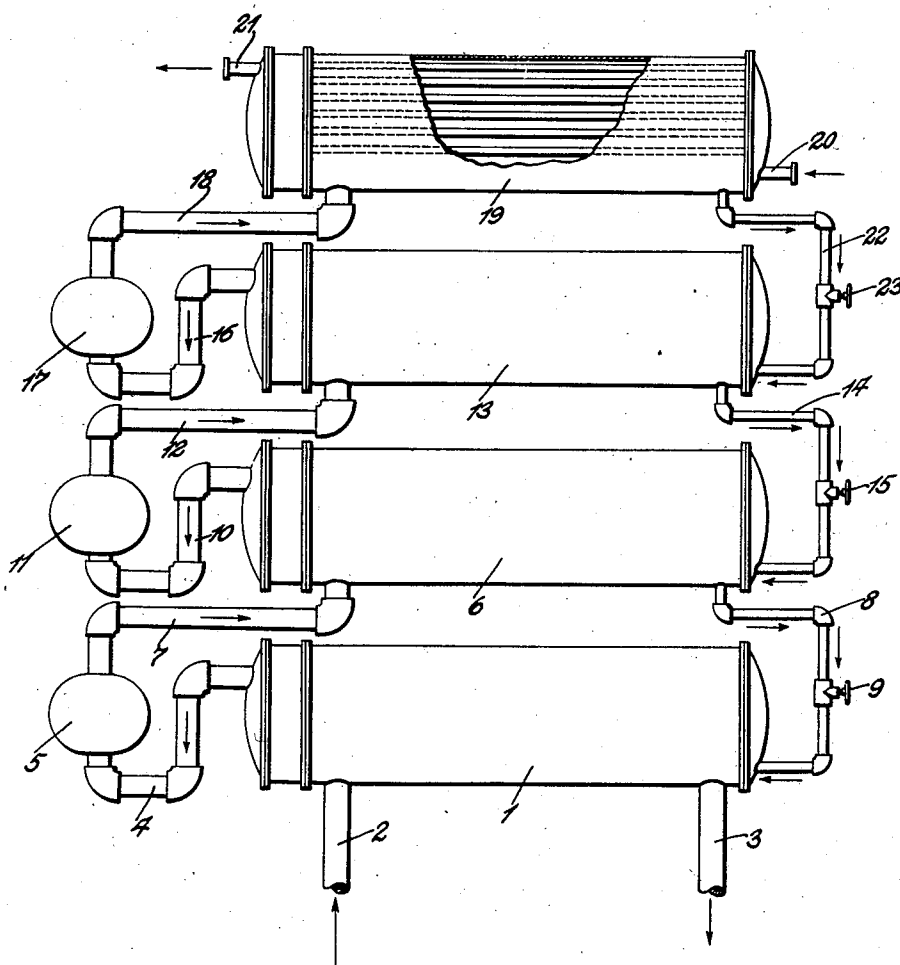
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REFRIGERATING PROCESS

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REFRIGERATING PROCESS

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This invention relates to improvements in refrigerating processes.

An object of the invention is to provide a multi-stage refrigeration process, using in each stage a compound hydro-carbon refrigerant characterized so as to give a low ratio of compression at the evaporating and condensing temperatures of each respective stage of the refrigeration cycle.

The drawing illustrates in diagrammatic form a plurality of refrigerating units with their connections.

The apparatus shown in the drawing is intended to be illustrative only and it will, of course, be understood that the practice of the process is not limited to any particular form of apparatus.

By providing a refrigeration process comprising a plurality of stages and by determining refrigerating agents having different evaporation points under predetermined pressures, and utilizing the refrigerating action of the refrigerant in the adjacent stage for condensing the evaporated liquid of the next stage, comparatively low pressures are required and lower temperatures may be attained without loss of efficiency.

For example, a series of hydro-carbon refrigerating agents, such, for instance, as methane, ethane and butane, may be utilized in a four-stage refrigerating process, so that the fluid to be cooled is subjected to the refrigerating action due to the expansion of methane, which, after expansion, is condensed by evaporating in the next adjacent stage the refrigerating agent comprising ethane, and then condensing ethane by utilizing the refrigerating agent butane, which in turn may be condensed under the cooling action of water at normal temperature.

While we have given an example of suitable refrigerating agents for the multi-stage process, mixtures made from selecting and compounding a hydro-carbon refrigerant differing for each stage and with a vapor pressure adapted to the pressure and temperature conditions of the particular stage, may be selected. Thus, the pressure under which the condensation of each refrigerant

takes place may be held at a relatively low ratio.

In the drawing, an apparatus for a four-stage system is illustrated. The fluid to be cooled is circulated around the tubes of an exchanger 1, the liquid being introduced through an inlet pipe 2 and discharged through a discharge pipe 3. Within the tubes of the exchanger 1, the most volatile hydro-carbon compound of the series used is evaporated, and the vapor of the refrigerant is withdrawn through the conduit 4 by a compressor 5, from which it is delivered to the exchanger 6 through a conduit 7.

In the tubes of the exchanger 6, a refrigerant of a lower degree of volatility is evaporated, which results in the condensation of the vapor of the next higher degree of volatility introduced into the exchanger 6. The condensed refrigerant is returned through a return passage 8 to the tubes of the exchanger 1, the passage 8 being controlled by an expansion valve 9. The vapor of the refrigerant expanded in the exchanger 6 in turn is conducted through a passage 10 to a compressor 11, from which it is forced under pressure through the passage 12 to the exchanger 13 in the tubes of which a refrigerant of a lower degree of volatility is evaporated, thereby condensing the vapor, which is returned through the passage 14 equipped with an expansion valve 15 to the exchanger 6 for re-evaporation.

The vapor of the refrigerant in the exchanger 13 is exhausted through the conduit 16, compressed in a compressor 17, and introduced through a conduit 18 into the exchanger 19, which is cooled by a flow of cooling water through the tubes thereof introduced through an inlet pipe 20 and discharged through a discharge pipe 21, the condensed vapor returning to the exchanger 13 through a conduit 22 equipped with an expansion valve 23. It is thus apparent that the vapor in each stage is compressed at low temperatures and at economical compression ratios.

It is contemplated that the whole apparatus will be heat insulated.

Any suitable means may be employed for supplying to each stage a sufficient amount of the refrigerant to make up for loss in evaporation and leakage, and instead of using a compressor for exhausting the vapor of the evaporating refrigerant, an absorption method may be employed.

It is not intended to limit the process by the use of any particular apparatus, but what is claimed and desired to be secured by Letters Patent is:

1. A refrigeration system which consists in expanding a series of refrigerants or different boiling points, subjecting the vapor of the expanded refrigerant of the lower boiling point to the cooling action of the refrigerant of higher boiling point, the last of said series of refrigerants condensing at substantially atmospheric pressure, and subjecting a fluid to be cooled to the cooling action of the low boiling point refrigerant.

2. A system of refrigeration which comprises the progressive expansion and condensation by compression and cooling of a series of refrigerants having varying boiling points from a boiling point at which the refrigerant condenses at substantially atmospheric pressure to a point sufficiently low to substantially cool a fluid, and subjecting the fluid to be cooled to the cooling action of the low boiling point refrigerant.

3. A method of refrigeration comprising the alternate evaporation and condensation of a graded series of refrigerating agents, the high boiling point refrigerant condensing approximately at atmospheric pressure and atmospheric temperature, and subjecting the material to be cooled to the cooling action of the lowest boiling point refrigerant only.

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