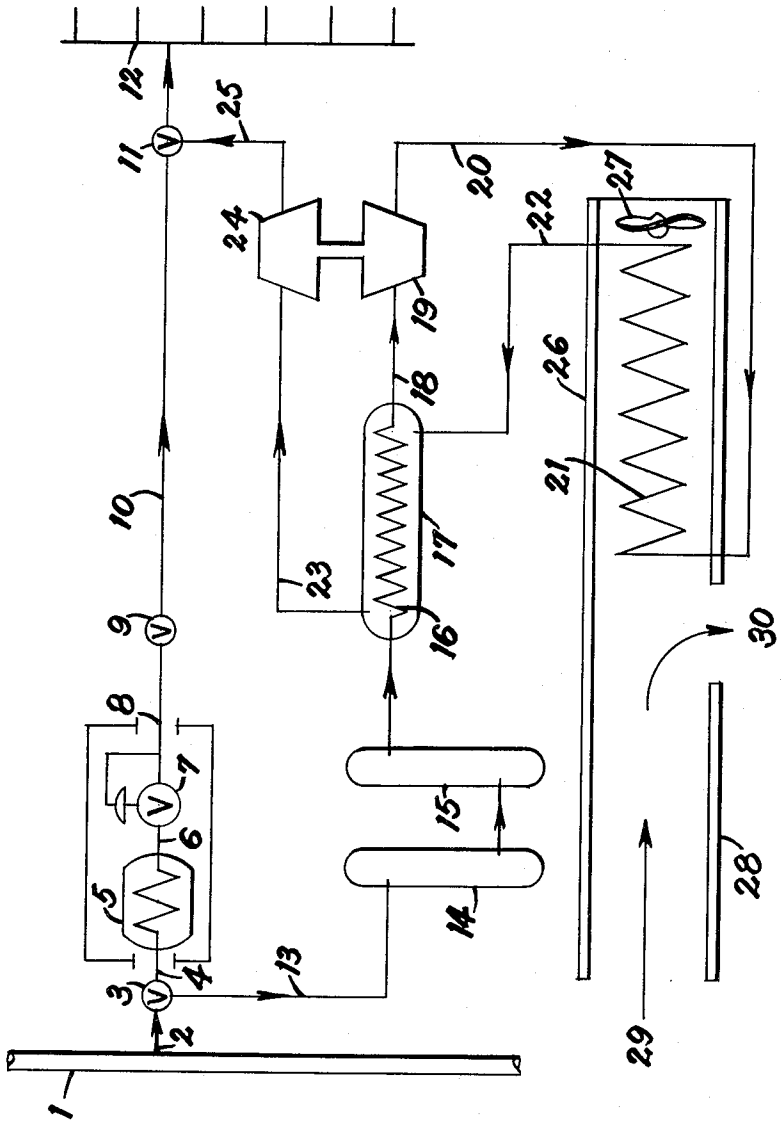
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NATURAL GAS EXPANSION REFRIGERATION SYSTEM

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NATURAL GAS EXPANSION REFRIGERATION SYSTEM

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This invention relates to improvements in refrigeration systems and has for one object to provide apparatus for and a method of using the high pressure gas in a cross country gas transmission line to provide effective refrigeration at one or more points along the line.

Gas is transmitted in cross country transmission lines at high pressure. At various points along the line where gas is to be used, it passes from the high pressure transmission line through a city gate station or similar discharge and metering plant for reduction in pressure and discharge for use. I propose to take advantage of the reduction in pressure at such point or points to obtain refrigeration.

The normal function of the city gate station is to receive the gas at high pressure (usually about 800 p.s.i.g. and 80 degrees F.) from the cross country transmission system and feed the required gas demand into the city main system, to maintain its pressure at about 25 p.s.i.g. In many instances, it is normal practice to install a gas heater ahead of the break-down regulator to counteract the refrigeration produced by the Joule-Thompson expansion and to assure that no regulator freezing would occur.

The basis of this invention is to utilize the refrigeration effect, which is further intensified by performing the expansion in a polytropic process to a pressure lower than city main pressure and then using the extracted work to compress the expanded gas from this reduced pressure to city main pressure with a turbo machine.

Under ordinary circumstances there will be a continuous flow of gas from the transmission line to the distribution system but as demand varies, the amount discharged will also vary. I propose to take advantage of the continuous supply of part of the gas to continuously recover useful refrigeration.

Such an arrangement will usually only utilize a proportion of the total near to or below minimum city demand and that the city gas regulator would necessarily remain in service to satisfy the daily demand fluctuations.

The flow path through the proposed system will divide the main high pressure gas stream ahead of the city gate station, conducting that quantity representing the city minimum demand requirement to the inlet of the proposed refrigeration plant.

The first step is to thoroughly remove those stream components such as water vapor and carbon dioxide that might deposit on an expander rotor. Next the gas stream is conducted through a precooler to recover any refrigeration ability rejected by the cycle. From the precooler the gas passes through a work extracting turbine where the gas temperature is reduced to —108 degrees F.

The cold exhaust gas will be conducted through a heat exchanger where by heat exchange it will rise in temperature, for example to 55 degrees F. and flow to the inlet gas precooler above referred to, thence to the inlet of the turbo compressor. The turbo compressor will utilize the work produced from the above expansion to compress the gas back to city main pressure, about 25 p.s.i.g.

The heat exchanger may be used in an air refrigeration tunnel to cool ambient air from 80 degrees F. down to —83 degrees F., such cooled air being used to cool any suitable commodity which may pass through the refrigeration tunnel.

On the other hand, the heat exchanger may be used by heat exchange with some element in a liquid nitrogen production plant to furnish part of the cold necessary to obtain liquid nitrogen from the air, such liquid nitrogen may then at atmospheric pressure be shipped to a point where it is used as a refrigerant.

Other objects will appear from time to time throughout the specification and claims.

My invention is illustrated diagrammatically in the accompanying drawing which discloses a flow sheet which illustrates the use of the heat exchanger in an air refrigeration chamber but it will be understood other uses as above referred to for the refrigeration effect may be equally effective.

Like parts are indicated by like characters throughout the specification and drawings.

In the flow sheet, the cross country transmission line **1** carries gas at high, perhaps 800# pressure. The main **2** leads from the transmission line to a distribution valve **3**. From the distribution valve **3**, a duct **4** leads to a gas heater **5**. From the gas heater **5**, a duct **6** leads to the expansion valve **7**. A duct **8** leads from the expansion valve **7** to a metering valve **9**. The duct **10** leads thence through the control valve **11** to the city main system **12**. All the above is in accordance with usual city gate station practice except that the valve **3** may be adjusted to distribute part of the gas from the duct **2** into duct **4** and part of the gas into the duct **13** which leads to the refrigeration part of the system. The duct **13** leads to a carbon dioxide extractor **14** which in turn discharges to a water extractor **15**. The gas from the water extractor at 800# pressure and 80 degrees F., passes through the coil **16** in a precooler **17** from which gas is discharged through the duct **18** at 890# pressure and 65 degrees F. to a turbo expander **19** where it expands, doing work and is reduced in pressure to 25# p.s.i.g. and —108 degrees F. This cold low pressure gas passes through the duct **20** to the refrigeration heat exchange coil **21**, thence it passes at 23# pressure and 55 degrees F. through the duct **22** to the heat exchanger **17**. From there the gas passes through the duct **23** at 20# pressure and 70 degrees F. to the compressor **24**. The compressor is driven by a turbo expander, the work of which passes the gas from 20# up to 25# and discharges it at 85 degrees F. through the duct **25** to the city main control valve **11**.

The heat exchanger refrigeration coil **21** may for convenience be located in an air cooling chamber **26**. A fan **27** forces ambient air at 80 degrees F. through the heat exchange air refrigeration chamber where it is cooled by the coil **21** and discharged into a product chill tunnel **28** at —83 degrees F. The product to be chilled may enter the tunnel at **29** and be discharged at **30**.

As above indicated, the refrigeration heat exchanger **21** may form part of a liquid nitrogen plant, the details of which form no part of the present invention and so are not illustrated but such a plant would utilize the cold gas in the refrigeration heat exchange coil to provide part of the cold necessary for the production of liquid nitrogen, which liquid nitrogen can then be used in place or shipped elsewhere as a refrigerant.

The important thing here is that instead of wasting all the heat necessary to protect the city main system from the Joule-Thompson effect as the pressure drops from, say, 800# down to 25#, I am using part of but not all of the Joule-Thompson effect amplified by the turbo compressor combination to obtain useful refrigeration, whether it is used in place as a coolant or as part of a gas reduction process being beside the point.

I claim:

1. In a gas distribution station having a high pressure gas main, a low pressure gas main and an expansion valve between them, a refrigeration means in par-

allel with the expansion valve including a heat exchange pre-cooler, a turbo compressor, a turbo expander and a heat exchange refrigeration coil, means on the upstream side of the expansion valve for discharging gas from the high pressure main, conducting it through the pre-cooler to the turbo expander where it does work with resultant fall in temperature and in pressure to a point below the pressure in the low pressure main, means for passing the cold gas through the refrigeration heat exchange coil and through the pre-cooler, to the turbo compressor where it is compressed to a pressure the same as that in the low pressure main and means for supplying it to the low pressure main.

2. A gas refrigeration means including in series a source of high pressure warm gas, means for cleaning it, means for cooling it, means for causing it to do work with resultant reduction in pressure and temperature, means for using the resultant cold gas by heat exchange as a refrigerant, means for warming the gas, means for compressing it and means for discharging it from the system.

3. A gas refrigeration system including a heat exchange pre-cooler, a turbo compressor, a turbo expander and a heat exchange refrigeration coil, a source of high pressure warm gas, means for conducting such gas through the heat exchange pre-cooler to the turbo expander where it does work with resultant reduction in temperature and pressure, means for conducting the cold gas from the turbo expander through the heat exchange

refrigeration coil and through the heat exchange pre-cooler to the turbo compressor where it is compressed and means for discharging the compressed gas from the system.

4. A gas refrigeration system including a heat exchange pre-cooler, a turbo compressor, a turbo expander and a heat exchange refrigeration coil, a source of high pressure warm gas, means for conducting such gas through the heat exchange pre-cooler to the turbo expander where it does work with resultant reduction in pressure and temperature, means for conducting the cold gas from the turbo expander through the heat exchange refrigeration coil and through the heat exchange pre-cooler to the turbo compressor where it is compressed to a pressure below that of the high pressure gas but above that of the gas in the refrigeration coil and means for discharging the compressed gas from the system.

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