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A refrigeration system for the temperature calibration of radiosondes

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ABSTRACT. The paper describes a deep freeze refrigeration system constructed by the authors in the Instruments Division of the Meteorological Office at Poona, and used for the temperature calibration of radiosondes. The refrigeration system using Freon 22 and Freon 13 in a cascade operation cools four calibration chambers to —70°C in about 1 hr 30 min.

1. Introduction

Deep freeze refrigeration system using propane and ethane as refrigerants, have been in use in the radiosonde calibration laboratories of the Instruments Division of the Meteorological Office, Poona for many years. The equipment described by Venkiteshwaran (1950) uses the cascade system of refrigeration, in which ethane is used as the primary refrigerant to cool a large chilling chamber and a second refrigerant propane is used to condense the ethane. The chilling chamber is filled with trichloroethylene, which circulates in copper coils surrounding the radiosonde calibration chambers, cooling them to any desired temperature to —70°C. More efficient direct cooling of the calibration chambers by the refrigerant itself was later introduced. A refrigeration unit using Freon as refrigerant was added in 1954.

With increasing demands for calibrated radiosondes, the need for additional refrigeration units was urgent. Since cascade refrigeration units are not yet assembled in India and the import of these complicated and expensive equipment would have involved large expenditure in foreign exchange, it was decided to construct such a unit at Poona.

2. Description

The refrigeration system chosen was one using Freon 22 and Freon 13 as refrigerants and was completed in 1962. Both F-22 and F-13 are non-toxic and non-inflammable and F-22 has the added advantage of being readily available in India. The refrigeration circuit diagram is given in Fig. 1 and the completed unit is illustrated in Fig. 2. The various components, particularly the compressors, motors, valves, controls etc used in both stages have been designed to be identical in order to minimise the number and types of components. Standard parts readily available in India have been used as far as possible.

Both F-22 and F-13 systems are identical and consist of compressors coupled to 1 H.P. motors, oil separators where the oil mixed with the gas is separated and returned automatically to the compressor crank case, condensers, receivers, heat exchangers, expansion valves and a series of regulator and relief and discharge valves with low pressure and high pressure cut-out controls, to ensure that the system works with maximum efficiency and economy.

The two systems are outlined in Fig. 1. Hot compressed F-22 gas at 150 lb pressure from the compressor C, passes through the oil separator O to the water cooled condenser W, where it is cooled and condensed. F-22 now in liquid form, passes through the receiver R, service valves SV and drier filter F to the heat exchanger H, where it is pre-cooled to about —30°C by the cold F-22 gas returning from the cascade condenser CC. At the expansion

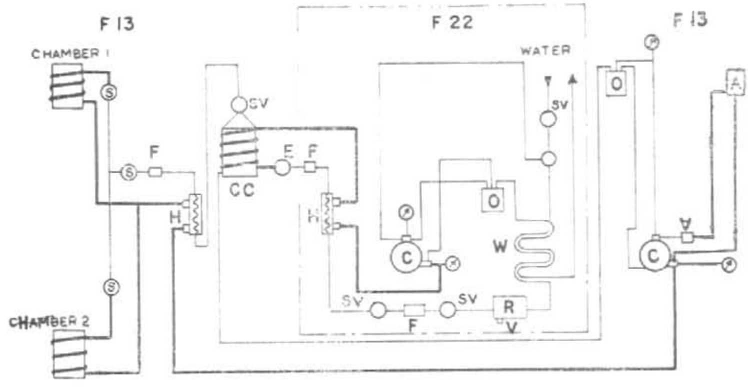

Fig. 1. Refrigeration circuit diagram

C—Compressor
E—Expansion valve
S—Solenoid valve
H—Heat exchanger
SV—Service valves
A—Auxiliary reservoir for F 13
O—Oil separator
F—Drier filter
V—Relief valve
W—Water cooled condenser
R—Receiver
CC—Cascade condenser

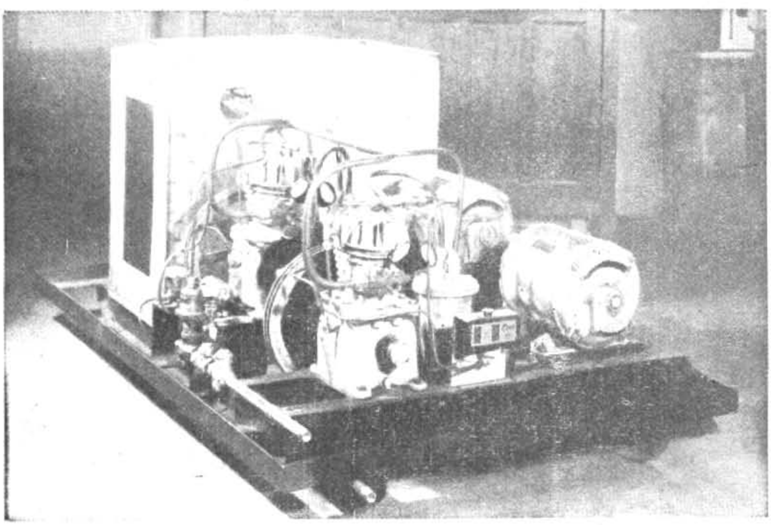

Fig. 2

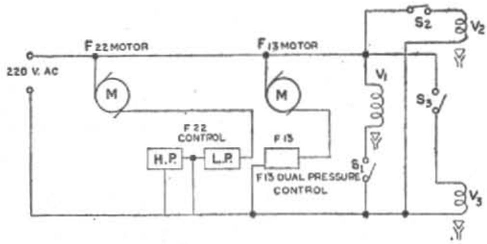

Fig. 3. Electrical wiring diagram

V_1—Main solenoid valve

V_2—Solenoid valve for chamber No. 1

V_3—Solenoid valve for chamber No. 2

valve E, the liquid F-22 is metered out to the low pressure side of the F-22 system, where the pressure is kept at approximately zero pounds. The liquid F-22 evaporates and cools to about —43°C. The low pressure side is the outer tube of the cascade condenser, which contains hot F-13 gas, which gives up its heat to liquid F-22 and converts it to vapour. The cold vapour returns to the compressor after passing through the outer coils of the F-22 heat exchanger H pre-cooling liquid F-22. The F-22 cycle is now complete.

The F-13 system is similar. Beginning as hot, compressed gas at 90 lb pressure, F-13 passes through the oil separator O and is first cooled by the returning cold F-13 and F-22 gases in a parallel heat exchanger and further cooled to —45°C and condensed by the cold F-22 gas. The F-13 in liquid form is pre-cooled to about —80°C by the returning cold F-13 gas in the F-13 heat exchanger H. At the solenoid valves S the liquid F-13 is metered out into the low pressure side of the F-13 system, which form the cooling coils of the radiosonde calibration chambers. The pressure in these coils, is about zero pounds and as the drops are released, they boil cooling to about —90°C. The cold F-13 gas returns to the F-13 compressor *via* the F-13 heat exchanger and the cycle is completed.

Relief valves V are provided in both systems, so that whenever the pressure exceeds safety limits, the gas escapes into the atmosphere for the F-22 system and into the low pressure side for F-13 system. An auxiliary reservoir A is provided in the F-13 system to accommodate the released gas.

The whole F-13 system is fitted inside an insulated box. The parallel heat exchanger containing the cold F-13 gas and cold F-22 gas lines coming from the respective heat exchangers are also insulated.

The electrical controls (Fig. 3) consists of the F-13 refrigerant solenoid valves V_1, V_2 and V_3 and the corresponding switches S_1, S_2 and S_3, the F-13 dual pressure control and the F-22 low pressure and high pressure cut-out controls. The last prevents either refrigeration system working in case of the F-22 system cutting off due to presence of air in the F-22 system. The F-13 dual pressure control similarly protects the F-13 system.

With charges of about 5 lb of F-22 and 2 lb of F-13 the refrigerator takes 90 to 100 minutes to cool the chambers from +40° to —70° C. A meteorograph can, therefore, be put through a complete atmospheric similitude cycle in 1 hour 30 minutes. Allowing 15 minutes for warming up, the calibration equipment is again ready for use after every 2 hours.

3. Performance

Using minimum lengths of large bore copper tubing (10-13 mm internal diameter) and solenoid and control valves of adequate capacity, the system works efficiently and economically. It is possible to calibrate 18 F-type meteorographs with 4 calibration chambers working 12 hours a day.

REFERENCE

Venkiteshwaran, S. P. 1950 *India met. Dep. Sci. Notes*, **11**, 134.