CHAPTER 3

EXPERIMENTS ON REFRIGERATION PLANT WITH "FREON - 12" REFRIGERANT CHARGED

3.1 DESCRIPTION OF APPARATUS

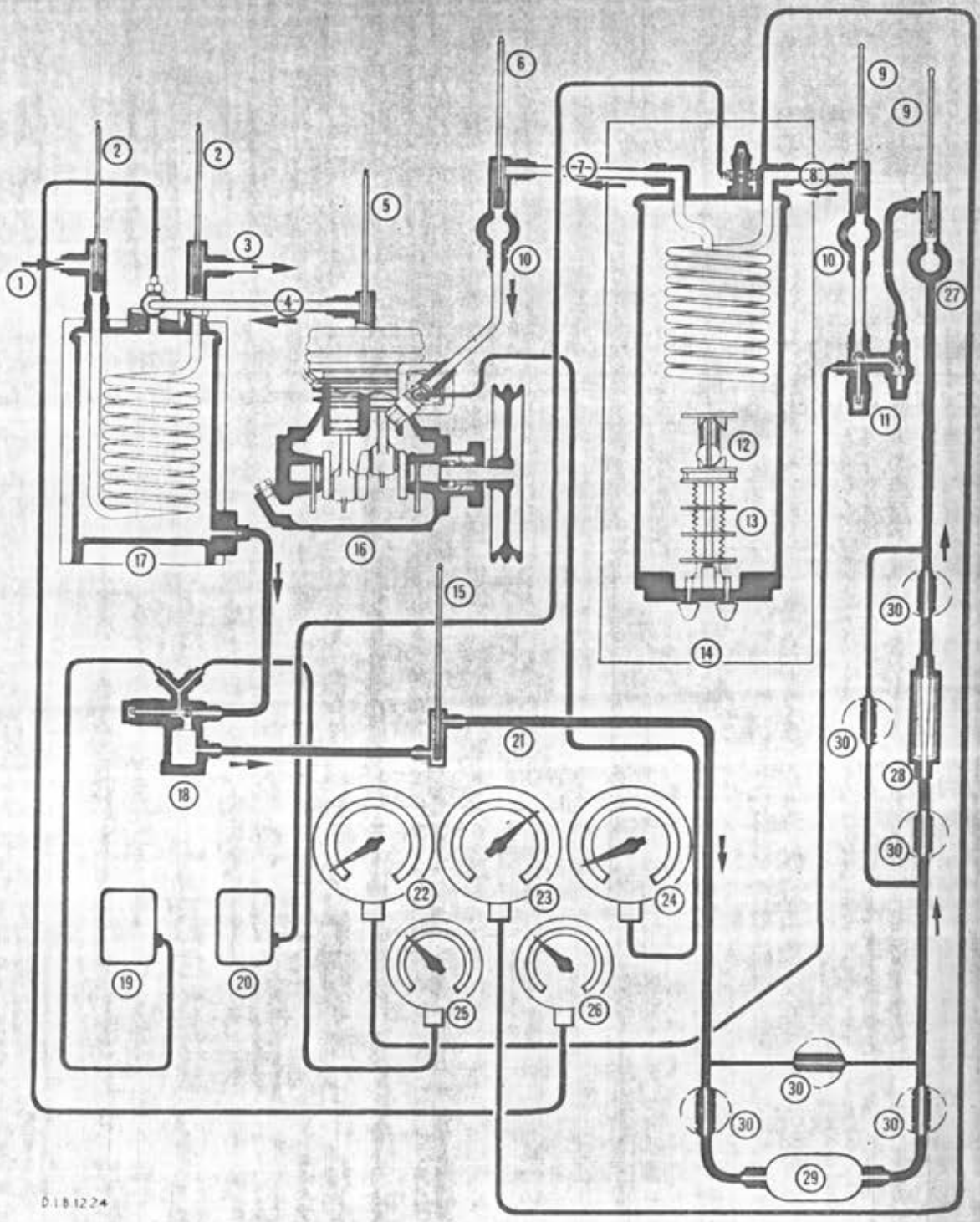
The refrigeration plant used for the experiment is the package type, see Photograph 1 in Appendix IV, manufactured by J. & E. Hall Limited. Dartford Iron-works, Dartford, Kent, England. The schematic diagram of plant is shown in Figure 3.1 The plant consists of the following main parts:

3.1.1. COMPRESSOR

The compressor is a 1.625 in. bore by 1.5 in stroke, twin-cylinder type, arrange for "V" belt drive. It is fitted with two thermometer pockets to measure the suction and discharge refrigerant vapor temperatures. A sight-glass is also fitted at the suction inlet, to enable a visual observation of the quality of the suction gas entering the compressor to be made. See Photograph 2 in Appendix IV and the cutting view of the compressor is shown in Figure 3.1.1.

3.1.2. DYNAMOMETER

The compressor is driven by a 1 horsepower dynamometer, Photograph 2 in Appendix IV, which enable a direct measurement of the compressor brake horsepower to be made.



1. Water Inlet.
2. Thermometers, +50° to +85°F.
3. Water Outlet.
4. Delivery Line.
5. Thermometer, +80° to +300°F.
6. Thermometer.
7. Suction Line.
8. Expansion Line.
9. Thermometer, —20° to +100°F.
10. Sight-glass.
11. Constant Pressure Regulator.
12. Float Switch.
13. Heaters.
14. Secondary Calorimeter.
15. Thermometer, —20° to +100°F.
16. Compressor, 1½" Bore, 1½" Stroke.
17. Water-cooled Condenser.
18. Liquid Stop Valve and Strainer.
19. H.P. Cut-out (Condenser).
20. H.P. Cut-out (Calorimeter).
21. Liquid Line.
22. Low Pressure Gauge, Expansion Line.
23. Low Pressure Gauge, Calorimeter.
24. Low Pressure Gauge, Suction Line.
25. High Pressure Gauge, Liquid Line.
26. High Pressure Gauge, Delivery Line.
27. Sight-glass.
28. Flowmeter (if fitted).
29. Liquid Line Drier (if fitted).
30. Stop Valve (if fitted).

FIGURE 3.7 Schematic diagram of refrigeration plant.

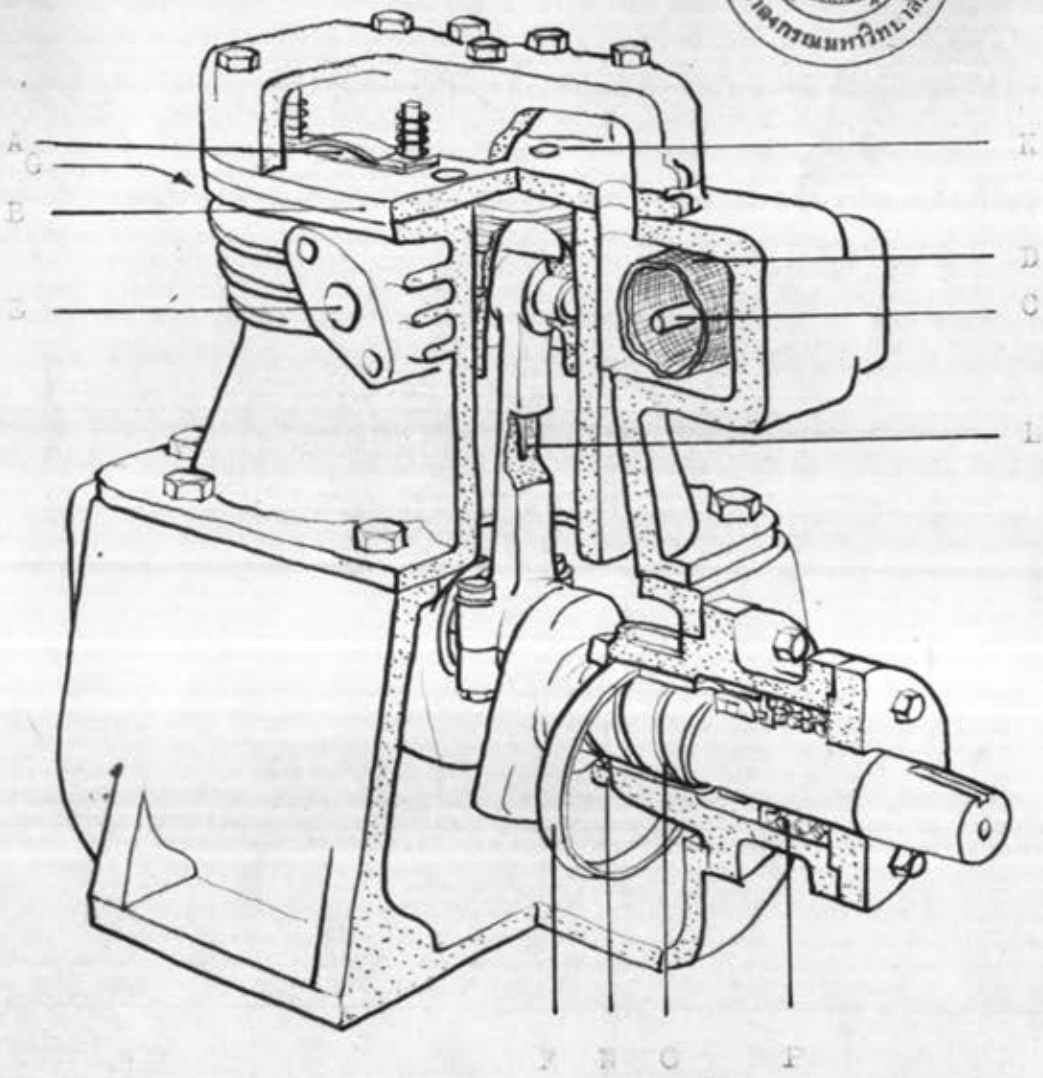


FIGURE 3.1.1 7 COMPRESSOR.

A-Delivery valve.
B-Valve plate.
C-Valve seat.
D-Suction strainer.
E-Delivery port.
F-Oil ring.
G-Connection for pressure calibrating unit.
H-Suction valve port.
I-Oilway in connecting rod.
J-Thrust washer.
C-Oil spiral.
L-Bellows gland.

3.1.3 CONDENSER

The condenser, which is water-cooled and of the shell and coil type as shown in Figure 3.1.3. It is mounted within the console on the right-hand side and to the front, see Photograph 3 in Appendix IV. Water to and from the condenser is fed via the two thermometer pockets situated on the left-hand side of the instrument panel.

3.1.4 CONSTANT PRESSURE REGULATOR

The regulator is, in effect, a pressure reducing valve. A typical arrangement is shown in Figure 3.1.4 and it will be seen that the inside of the bellows is subjected to evaporator pressure. on the upper side of the bellows is a spring. The pressure which this spring exerts can be adjusted by rotating the adjusting screw. When the pressure in the evaporator falls below the operating pressure to which the regulator is set, the spring will push the bellows downwards. The bellows operates the valve needle through a thrust pin located in a long guide; consequently, when the bellows move downwards the needle valve will also move away from the valve seat, thus allowing liquid refrigerant to pass into the evaporator. Similarly, when the desired pressure has been built up the needle valve will move upwards and stop the flow of liquid. In this way a constant pressure will be maintained in the evaporator.

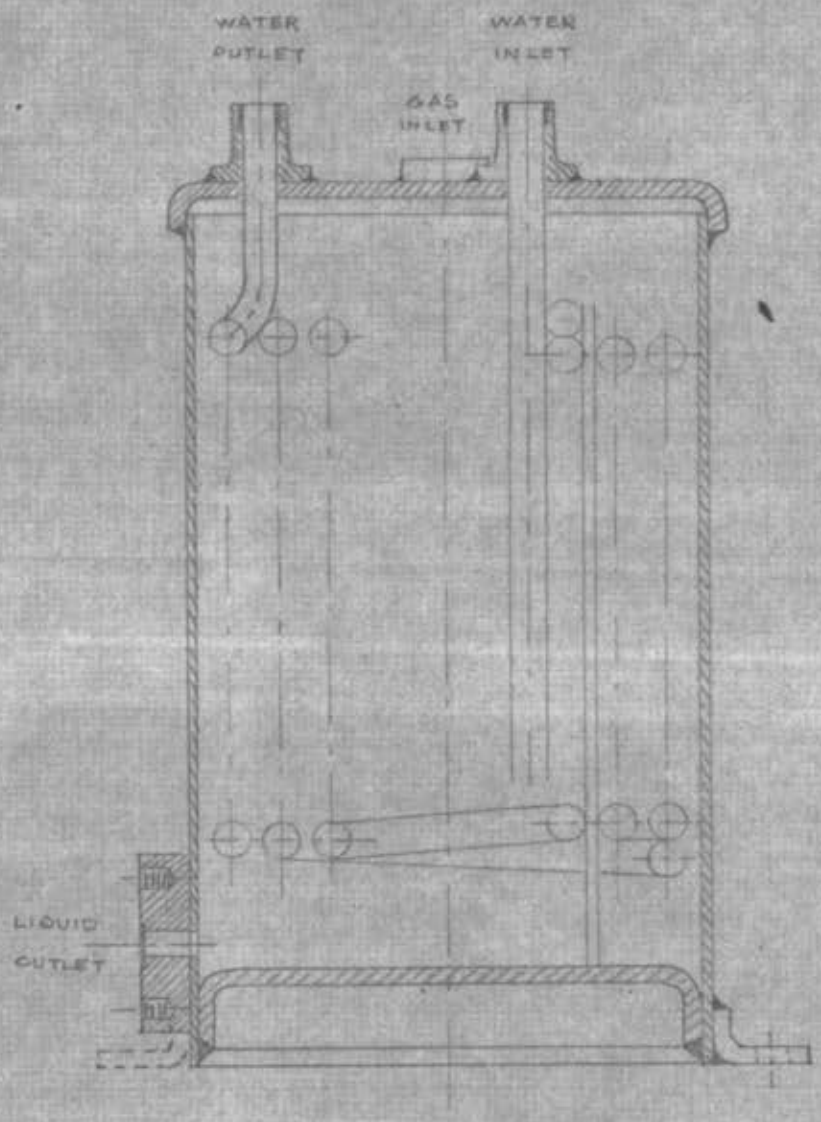
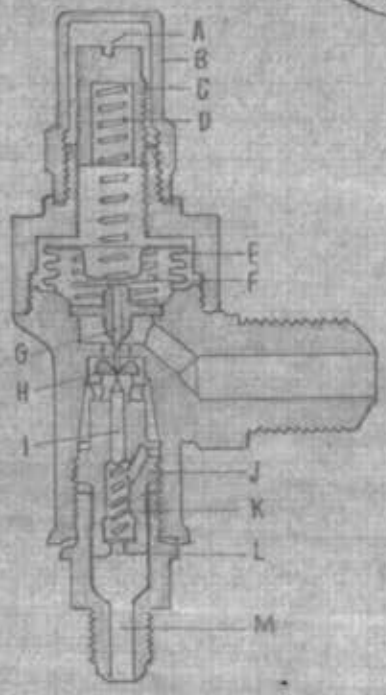


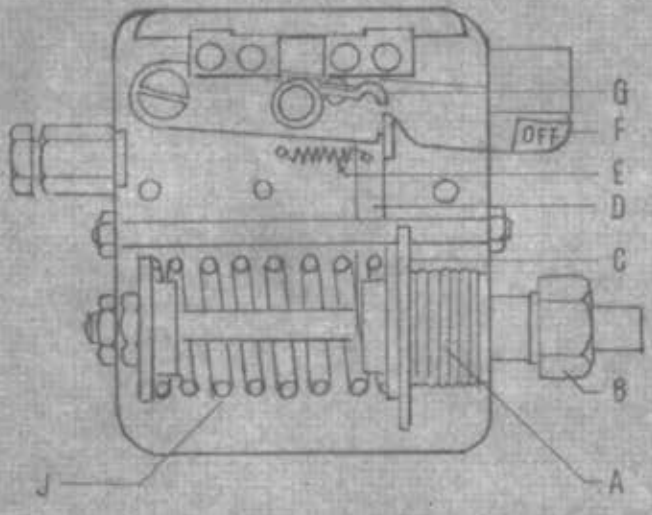
FIG. 3.1.37 WATER COOLED CONDENSER

SECTIONAL VIEW



A - Screwdriver Slot.
B - Brass Cap.
C - Adjusting Screw.
D - Range Spring.
E - Bellows.
F - Spring.
G - Thrust Pin.
H - Seat.
I - Needle.
J - Housing of Needle and Seat Unit.
K - Needle Spring.
L - Slot for Unscrewing needle and Seat Unit.
M - Inlet Connection.

FIG. 3.1.4 CONSTANT PRESSURE REGURATOR.



A - Bellows.
B - Tube connector.
C - Guide washer.
D - Switch arm catch.
E - Catch spring.
F - Switch arm.
G - Spring contact.
J - Spring.

FIG. 3.1.6 MECHANICAL TYPE HIGH PRESSURE SAFETY CUT-OUT.

3.1.5 SECONDARY REFRIGERANT CALORIMETER

The secondary refrigerant calorimeter comprises a pressure-tight vessel in the form of a vertical shell, containing in the upper half the "Evaporator" and in the lower half an "Electrical Heater" with a float switch assembly which has both high and low level contacts.

The evaporator is manufactured from copper tubing formed into concentric coils, the refrigerating effect produced cools the evaporator coil, which in turn condenses the secondary refrigerant vapor contained in the calorimeter shell, onto its outer surface.

The heater is immersed in liquid Refrigerant-12. It has a total output of 3 kilowatts and is divided into two sections. One section has a fixed capacity of 1.5 kilowatts, and the second, variable capacity up to a maximum of 1.5 kilowatts, controlled by a "Variac" Autotransformer.

3.1.6 THE ACCESSORIES

a. PRESSURE GAGE

Five pressure gages are provided on the instrument panel, to record the following information:

Delivery line-high pressure gage 30 in.Hg.- 200 psig.

Liquid line-high pressure gage 30 in.Hg.- 200 psig.

Expansion line-low pressure gage 30 in.Hg.- 100 psig.

Suction line-low pressure gage 30 in.Hg.- 100 psig.

Calorimeter-low pressure gage 30 in.Hg.- 100 psig.

b. WATTMETER

A dual range wattmeter is provided to indicate the power input to the electrical heater.

c. THERMOMETER

Eight thermometers are provided to record the room temperature and put on seven thermo-pocket, to record the temperatures as follows:

Compressor suction gas.

Compressor delivery gas.

Liquid at condenser outlet.

Liquid at the regulator.

Expansion line.

Condenser water inlet.

Condenser water outlet.

d. FLOWMETER.

Two flowmeters are fixed on two sides of the instrument panel to record the following information:

The amount of condenser water flow.

The amount of liquid refrigerant flow.

The illustration of liquid refrigerant flowmeter is shownin Photograph 4 in Appendix IV.

e. HIGH PRESSURE SAFETY CUT-OUT.

Cut-outs are provided on both the primary and secondary refrigerant circuits to protect against excessive pressure. The high pressure cut-out on the calorimeter secondary system will break the electrical circuit to the heater if the pressure exceeds approximately 100 psig. The cut-out on the primary system will open the electrical circuit to the dynamometer if the pressure exceeds 200 psig. Figure 3.1.6(e) is shown a mechanical type high pressure safety cut-out.

f. CONTROL PANEL.

The control panel as shown in Photograp 5 in Appendix IV placed at the top of the console has grouped on it the following:

Dynamometer switch. OFF - ON.

Calorimeter switch. OFF - NORMAL - OFF - CHECK.

Variable transformer. 0-260 for variable heat control.

Heater/wattmeter. Range switch. LOW - HIGH.

Liquid level indicator lamp.

g. STOP WATCH, BEAKER AND BALANCE.

The flow of condensing water can also be measured by stop watch, beaker and balarnce.

h. TACHOMETER

The speedsof motor and compressor are recorded by tachometer.

3.2 TEST PROCEDURE

The plant was operated as following steps:

- Open the condensercooling water valve.
- Plug in electric cord to power supply.
- Switch the main switch to "ON".
- Switch dynamometer to "ON".
- Switch the calorimeter to "NORMAL".
- Switch heater to "LOW"or "HIGH"depending on the evaporator load.

When the unit is operating correctly, it should be allowed a period of time for the conditions to become steady. Small adjustments to alter the operating condition can be made as follow:

1. The evaporator pressure is controlled by adjustment of the constant pressure regulator.

2. The suction temperature or an amount of superheat can be controlled by adjustment of the heat input. When an increase in superheat is required for a fixed evaporator pressure, the temperature (pressure) of the secondary refrigerant must be increased; this will follow an increase in heat input.

3. The condenser pressure can be controlled by adjustment of the amount of condenser coolingwater flow.

4. The dynamometer is balanced by the balance weight.

5. The direct measurement of condensing water circulated through the condenser can be made by allowing the water flow in a beaker and record the time by a stop-watch, then weighing by a balance.

6. Speed of dynamometer and compressor can be known by using tachometer.

The performances of the "Freon-12" plant were carried out under two following conditions:

1. At constant suction temperature (superheat-temperature), and varying the evaporator (suction) pressure.

This test involved various settings of the suction pressure from 10-30 psig for constant refrigerant suction temperature of 85 F and the condensingpressure was kept around 140 psig throughout this set of tests. All readings were recorded as shown in Table 3.1 in Appendix I

2. At constant evaporator pressure and varying degree of superheat of suction temperature.

The evaporator (suction) pressure of 21 psig was maintained constant by the pressure constant expansion valve and the degree of superheat was varied from 34 F to about 76 F. The condensing pressure was also maintained at 140 psig. Table 3.2 in Appendix I shows all readings of each test.

3.3 TEST RESULTS

The results of experiment on "Freon-12" plant, at constant suction temperature and varying the evaporator pressure, are shown in Table 3.3, Graph 1, and Graph 2 in Appendix III. And Table 3.4, Graph 3, and Graph 4 in Appendix IIIshow the results which test at constant evaporator pressure and varying degree of superheat of suction temperature.