DOMESTIC REFRIGERATORS

Operation and Maintenance

PART I

by

R. SHEARMAN
Engineer-in-Chief's Department.

Domestic refrigerators are provided by the Admiralty for approved services in H.M. Ships and with the large numbers now fitted, maintenance has become a major problem. Information reaching the Admiralty indicates that although D.A.Rs. are designed for use in the tropics and tested at the makers works under tropical conditions, the general performance onboard leaves much to be desired. The time and effort required to maintain them has been compared unfavourably with that for the ship's main machinery.

Discretion in the use of the Refrigerator

The refrigerator has to operate under full load for as much as 16-20 hours per day particularly so in the tropics. Unless adequate maintenance is provided and the unit used with discretion, poor performance and eventual total disablement will occur.

Refrigerators are intended to operate with the doors closed. Each time the doors are opened infiltration of heat takes place ; the smaller the cubic capacity of the unit the greater is the proportional infiltration. If, therefore, doors remain open for longer than is essential, the capacity of the cooling units—which is necessarily limited by considerations of weight and space—will be insufficient to maintain the designed cabinet temperature. Continual running of the machinery results, causing rapid wear and eventual breakdown.

The first essential is, therefore, to use the refrigerator with discretion, i.e., to limit the number of times the doors are opened, the length of time they are open being as short as possible. Hot food should *never* be put in the cabinet ; it should first be allowed to cool to the ambient temperature. The refrigerators at present supplied are of the vapour compression type and designed to operate satisfactorily when the ambient temperature is not more than 110°F.

Correct running Conditions

The refrigerant effect is obtained by the evaporation (boiling) of the refrigerant within the evaporator or low pressure side of the system. It is dependent on the *weight* of refrigerant flow and unless the amount is adequate for the duty, the refrigerator will fail to cool sufficiently. The refrigerant flow depends on the difference in pressure across the expansion valve, the density (*specific weight*) of the refrigerant within the evaporator, and the size of the expansion valve orifice. The size of the orifice is decided by the maker of the plant who fits a valve suitable for the duty, but the pressure difference varies according to the ambient conditions. The conditions can, however, be generally stated as follows :—

(i) *the condensing pressure* in the condenser and high pressure side of the expansion valve (shown on the condenser gauge) is correct when the corresponding temperature shown on the gauge is 20° - 25°F above the temperature of the air passing on to the condenser.

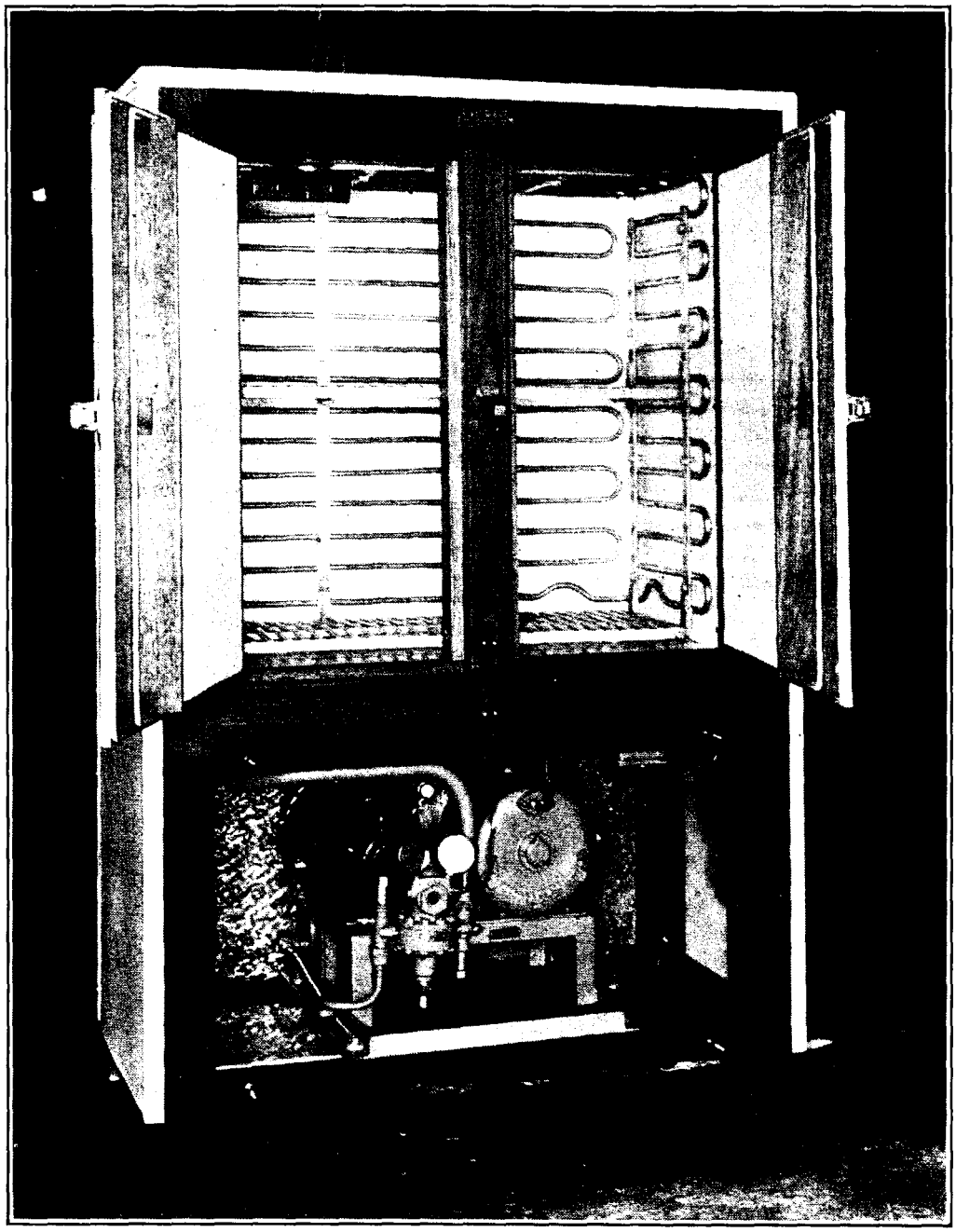

FIG. 1.—HALLMARK CABINET

(ii) *the specific weight and pressure* of the refrigerant in the evaporator will be correct when the corresponding temperature shown on the suction gauge is 20° - 30°F below that of the temperature of the cabinet.

Unless the above conditions are attained the plants will be incorrectly charged. If the condenser and, or, the evaporator gauge readings are lower than those quoted, the plant will be undercharged and inefficient cooling will result. Adjustment of the setting of the expansion valve will not rectify the undercharge but will only transfer the state of undercharge from one side of the circuit to the other.

Conversely, if the gauge readings are higher than those shown at (i) and (ii) the plant may be overcharged, causing overloading of the driving unit. High

condenser gauge readings with correct evaporator gauge readings may be caused by air or other non-condensible gases in the system. The state of the liquid in the liquid sight glass should be observed in conjunction with the above readings. In a properly charged plant the glass should be at least three quarters full and free from bubbles.

On some machines, notably the Hallmark 15 cubic feet models, an oversize condenser may be fitted ; such plants will be correctly charged when the temperature difference between the condenser gauge readings and the air on the condenser is only 10° - 15°F. The evaporator pressure should be as stated in (ii) with the liquid sightglass nearly full, and free from bubbles.

Checking and Adjusting

When the above conditions have been attained, the evaporator, but *not* the suction pipe to the compressor, should be completely frosted and the compressor discharge pipe just too hot to hold. This check is used almost invariably by refrigerator engineers. If the suction pipe is frosted the expansion valve should be closed slightly, the plant allowed time to settle down, and the result observed. Further small adjustments should be made until the suction pipe is free of frost. Adjustments to expansion valves should always be made in stages and the plant allowed to settle between each adjustment.

The importance of maintaining the correct charge cannot be over emphasised. An undercharge is the forerunner of many troubles, e.g., long running time of the compressor ; frequent starting and stopping of the machine which causes rapid wear of thermostat contacts and overheating of the electrical equipment, and the loss of oil from the crankcase to the condenser which in turn causes rapid wear of bearings and damage to the compressor gland seal. It is essential that the joints and connections in the gas circuit should be kept tight ; joints slack back due to vibration and gunfire, and periodic checking of these will do much to prevent loss of refrigerant with its attendant evils.

When charging the plant or adding refrigerant (topping up) and also when adding lubricating oil to the compressor, prevention of moisture entering the system is of primary importance. It is advisable to connect the drier (dehydrator), if not permanently connected, at such times. Care should be taken not to run the plant with a saturated drier.

Condenser

With D.A.R. machinery the removal of the heat from and liquefaction of the refrigerant in the condenser is obtained by passing air over the condenser surface. The fan is incorporated in the compressor flywheel or the motor driving pulley, or both. Unless sufficient air passes over the condenser surface the refrigerant in the condenser will be insufficiently cooled, the refrigerant effect diminished, and long running of the machine on an inefficient cycle may be expected. The majority of refrigerators have been installed after the ship's completion date and difficulties were experienced in finding suitable sites. Many D.A.Rs. are adjacent to sources of wild heat and where air access to the condenser is restricted. If the backs of these units can be ventilated by hoses or other suitable means from the ship's ventilation system considerable improvement in performance should result. It is also important that the condenser surfaces should be kept clean.

Belts

The machines are belt driven. Belts stretch, especially when new, and unless the proper tension is maintained, slipping will occur causing loss of speed to the compressor and rapid wear of the belts. If the flywheel or motor pulley appear to be warm, the belts are probably slipping.

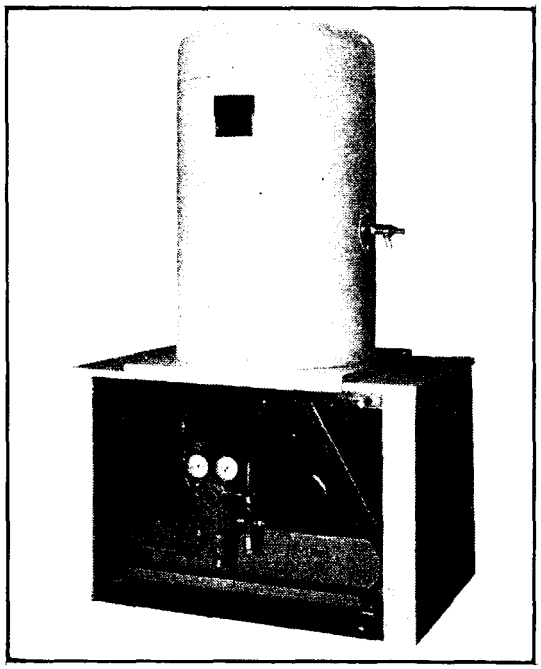

FIG. 2.—DRINKING WATER COOLER

Automatic expansion valve

The automatic expansion valve is, probably, the most troublesome item in all refrigerating plants, the thermostatic type being the worst offender in this respect. The trouble is mainly due to the necessity of using a commercial article which is insufficiently robust for the arduous duty onboard H.M. Ships. There is little that can be done when these valves prove faulty—apart from replacing the valve complete. It is suggested that when renewal of thermostatic valves becomes necessary they are replaced by the constant pressure type. (Attention is also invited to A.F.O. 4624/44.) The loss of cooling capacity which this would entail can be accepted for small domestic machines and would probably be compensated by a reduction in the maintenance required. Experiments are being carried out with a view to finding a more satisfactory type of refrigerant control, and if they are successful details will be promulgated.

Correct operation must be understood

The above remarks are applicable in general to all air-cooled machines, e.g., drinking water coolers and ice-cream plants, as well as D.A.R.s. In general, the maker's instruction books contain all the information necessary for the correct operation and maintenance of the plants, but the above defects with their remedies have been dealt with specifically, because from the reports from all classes of ships it is apparent that they are the most frequently recurring causes of breakdowns. Maintenance of large numbers of domestic machines, particularly with reduced complements, is often a difficult problem, but it is believed that if the correct conditions of operation are fully understood, much can be done towards obtaining maximum benefit from the amenities provided.

PART II

The following is an extract of a report from the British Pacific Fleet with the Fleet Engineer Officer's comment and remarks by the Engineer-in-Chief's Department.

The maintenance of the various " amenity " plants is becoming a serious problem on top of normal machinery maintenance, particularly with reduced and diluted complements.

With reference to the use of absorption type machines, H.M.S. *Glory's* latest report is of interest :—

" We have three in No. " Electrolux " type D.A.R.'s which have been on board for just on one year. The one fitted in the W.O.'s Mess has been the least satisfactory in that occasionally it has stopped functioning. The cure, is, however, simple and consists of waltzing it round the mess giving it a good shake

and turning it upside down for a few hours. On being righted and switched on it again functions. This operation does not have to be carried out very frequently. Of the other two, the one in the Sick Bay has given no trouble at all, whilst the one in the C.P.O.'s Mess has worked well except for the water freezer, on one side only, which fails to freeze hard.

" In view of the satisfactory working of these apparatuses, I am forwarding a separate report through R.A.A. to C.-in-C. recommending their general adoption. The only disadvantage appears to be that for a given number of B.Th.U. per hour the overall size is bigger. In these days of skilled ratings especially, this is far outweighed by the general reliability, complete lack of moving parts, and simplicity of cure for non-operation."

F.E.O.'s Comment

It is understood that official opinion is against the " absorption " type, but since this matter was raised in the B.P.F. in C.-in-C.'s Minute III No. 907/BPF/1142M of 22nd September, 1945, only one complete failure has come to notice, namely a kerosene operated Electrolux plant issued for trial to H.M. Tug *Enticer*.

Remarks

The difficulties attendant on the maintenance of " amenity " plants is fully realized and, contrary to your comment, official opinion is *not* against the absorption type of machine in principle, provided they could meet the specified conditions. The temperature required within the cabinet is 40°F. with an ambient temperature of 110°F., which is often exceeded due to bad siting. At this ambient temperature, the absorption type of machine will not produce a cabinet temperature of below 55°F. even with very restricted door openings.

It is felt, however, that in the future, with more care being given to the siting and ventilation of D.A.R.s, etc., it may well be that, even in the hottest weather, the temperature of the cooling air supplied to the condensers will not exceed 95°F., for other than short periods during the 24 hours, which will enable the cabinet to be maintained, with care, at 40°F.

Official action has been taken to provide air trunking and orders have been placed for a number of Electrolux machines to be given a trial under modern conditions.

Further current efforts to reduce maintenance include :—

(i) Provision of a greatly improved specification to manufacturers.
(ii) The use of A.C. driven sealed units. (These are being supplied to *Daring* Class destroyers and if successful steps will be taken to provide a suitable A.C. supply in D.C. ships.)