WORLD WIDE SUPPLIERS OF ELECTRONIC COMMUNICATIONS EQUIPMENT

Field Engineering Bulletin 22

METHODS OF COOLING HIGH POWER TRANSMITTERS

WATER COOLING

For many years the cooling of high power radio transmitters at military and commercial shore installations has been accomplished by the use of water wherein the plates of the final, and in some cases intermediate, tubes were actually immersed in continuously circulated water. The principal advantages of this system are its efficiency and quietness and its reserve capacity insofar as over dissipation of the tubes due to improper tuning, loading, operator error, or other causes. This method, however, required a bulky and complicated piping, pumping, control and cooling system, as well as the need for large quantities of water commonly stored in reservoirs. The disadvantages of such a system are quite obvious.

AIR COOLING

In recent years, in an attempt to reduce the physical size of high power equipments and eliminate complicated and bulky cooling methods, the trend has been toward air cooling of high power stages by means of self-contained, high velocity, high capacity blower systems. This together with the reduction in physical size of such things as tubes, transformers, variable capacitors, etc., has resulted in a radical and obviously advantageous reduction in the size and complexity of modern high power radio transmitters such as the AN/FRT-39, AN/FRT-40, and AN/FRT-62 equipments. The advantages of this method of cooling are quite obvious. However, there are disadvantages in the way of reduced tolerance to overload or abuse by mistuning or operator error, high acoustical noise levels, and heat generated in the space in which the equipment is installed. The high ambient noise level poses a serious problem in its impact on operating personnel as has been indicated by various surveys conducted by experts on the subject of acoustical noise levels versus efficiency and intercommunication ability of operating personnel. The release of tremendous quantities of heat within the transmitter building usually imposes intolerable loading on the ventilating or air conditioning system which cannot be economically solved by expansion of such a system. An alternative to such an expansion, which also serves to reduce the acoustical noise problem to some degree, is the use of intake and exhaust air ducts from each transmitter to the outside of the building. Although this is quite adequate as a means of removing the heat from the building and, to some degree, effecting a reduction of acoustical noise, it has some disadvantages, dependent on local ambient conditions, such as dust, salt and moisture content of the outside air, and temperature, which may result in deterioration of equipments due to corrosion, dust deposits, and overheating, thereby affecting equipment life and reliability. In addition, depending upon the size and configuration of the building and the density of transmitters installed therein, the physical size and routing of the intake and exhaust ducts may prohibit their use due to lack of space, restriction of movement of operating and maintenance personnel around the equipment, interference with overhead transmission lines, or other structural considerations. The placement of intake and exhaust openings in high density installations may become critical and pose a problem of exhaust heat entering the intake openings with consequent overheating of the equipments.

VAPOR COOLING

Vapor cooling, sometimes referred to as vapor phase cooling, which provides a means of cooling electron tubes by vaporization of water, more or less represents a compromise between water cooling and air cooling with some of the advantages and disadvantages of each. Basically, this technique exploits the high energy level required to change water from the liquid to the vapor state. The plate of the tube is immersed in distilled water in a boiler surrounding the tube. Power dissipated on the plate of the tube raises the water to the boiling point and steam is generated and transferred by convection to a heat exchanger where it gives off its energy and is condensed back into water. The water is then returned to the boiler via a reservoir and pumping and control mechanisms.

Figure 1 is a block diagram and data sheet relative to the vapor cooling system currently being evaluated in the AN/FRT-40 equipment. Figure 2 shows the system installed in the AN/FRT-40 transmitter. It should be noted that this system is entirely self-contained within the AN/FRT-40 with the exception of the heat exchanger which is located outside the transmitter building. The connections to the heat exchanger consist of a ¾" pipe for water return and a 1½" pipe for steam conduction.

The principal advantages of the vapor cooling system are the reduction of acoustical noise, the ease with which heat is transferred, and the extension of tube life due to a marked decrease in the operating temperature of the tube as opposed to the forced air system.

The principal disadvantages of the vapor cooling system are:

a. The system requires distilled water for satisfactory operation. This may pose a logistics problem in some areas.

b. The external heat exchanger must be protected in sub-zero weather to prevent freezing, and, depending upon ambient temperatures, may require forced air cooling.

c. The system will require more attention by maintenance personnel with regards to water levels, circulating pumps, and protective devices than is currently required with forced air cooling.

d. The final amplifier tube (ML-6697) in the AN/FRT-40 must be replaced by a type ML-7480 tube since the ML-6697 is not suitably configured for vapor cooling applications. The ML-6697 and ML-7480 are, however, identical electrically.

VAPOR COOLING PRINCIPLE

Vapor cooling systems apply the principle of latent heat of vaporization to achieve much higher rates of anode dissipation than is possible by conventional methods. In a typical system, a tube with a specially designed anode structure is immersed in a boiler nearly filled with water. The water at 95° C is converted to steam at 100° C, thus absorbing 540 calories per gram of water evaporated. As a result of this conversion, a 1600-fold volume increase creates a turbulent cleansing action around the heavily ribbed anode that assures nucleate boiling and prevents the stage of film boiling, whereby an insulating vapor film could lead to over heating and destruction of the tube. The expanding vapor passes through an insulated pipe into a heat exchanger where complete condensation is accomplished. The water then is returned by gravity flow to the reservoir.

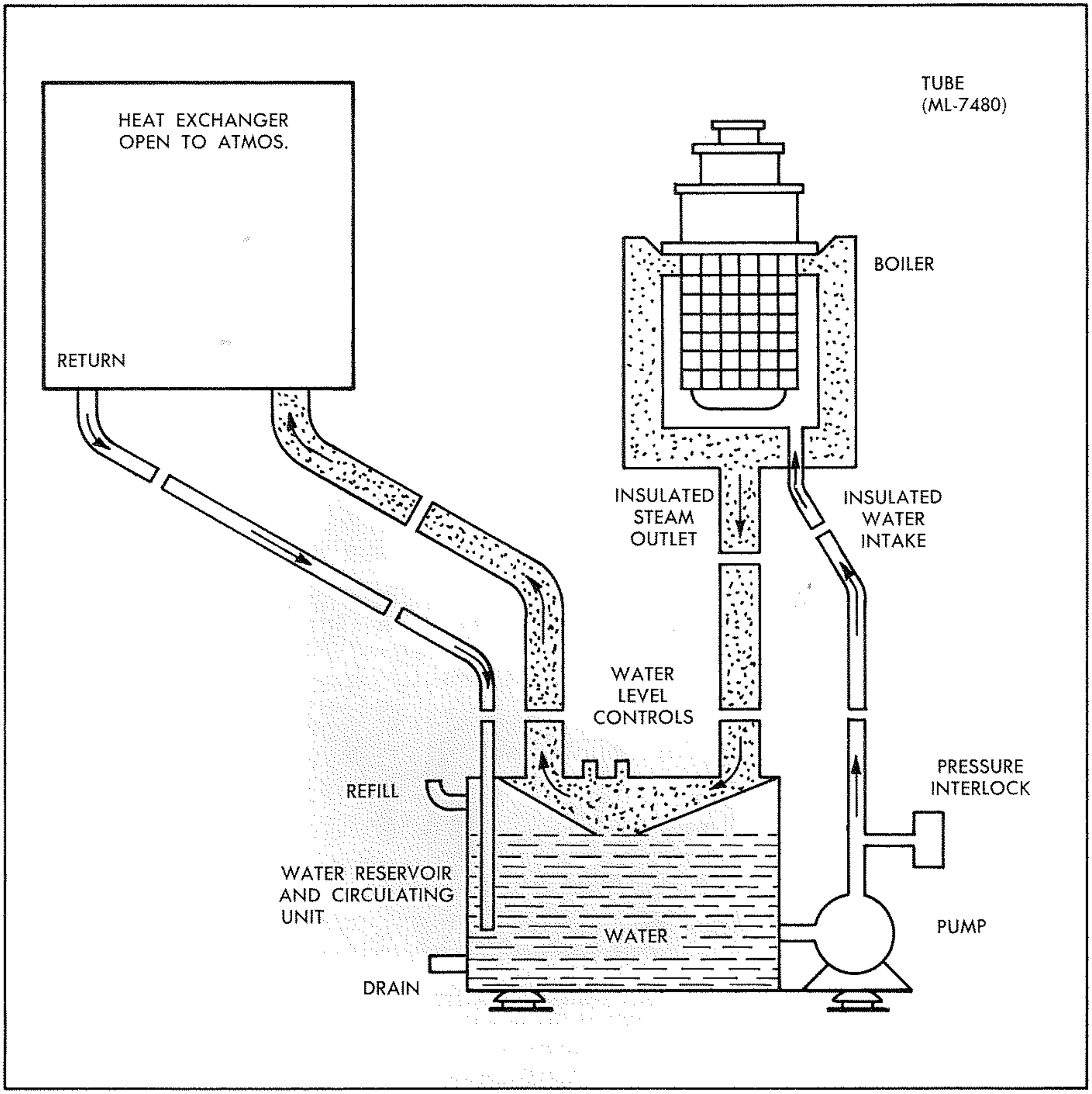

FIGURE 1. GPT-40K TRANSMITTER VAPOR COOLING SYSTEM.

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